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Western Europe

FRANCE:

Rafale flies with M88

Having flown since 4 July 1986 on the power of a pair of General Electric F404 engines, the Dassault Rafale came halfway to achieving its definitive powerplant on 27 February when flight tests began with a SNECMA M88 in the port bay. First to fly with a pair of the 87-kN (19,558-lb st) engines will be production prototype C01 in February 1991.

All-change for helicopters

With effect from 1 January 1990, Aérospatiale retrospectively amended the designations of its military helicopters, adding 200 to their model numbers and standardising on an 'AS' prefix to replace those previously using 'SA' to denote design by Sud Aviation. The move was prompted by a desire to provide an easy means of identifying those aircraft built to military specifications. Apart from the AS 342 Gazelle, which remains unchanged, the other helicopters now in production are the AS 332/532 civil/military Super Puma; AS 350/550 Ecureuil; AS 355/555 Ecureuil 2; and SA 365/565 Dauphin/Panther. Letter suffixes have also been modified: A – armed; C – anti-tank; M – naval; S – armed naval; and U – utility. Examples include the AS 355M Ecureuil II, which can now be AS 555UR, AR, MR or SR and the SA 365K Panther, which becomes AS 565AA/UA.

New Ecureuils accepted

Originally due in 1987, the first Turboméca TM319-engined AS 555UN Ecureuils for French military service were delivered to the Armée de l'Air helicopter OCU, CIEH 341, at Toulouse-Francazal on 19 January. Out of 50 Ecureuils required to replace Alouettes, the first six were delivered from 1983 onwards, powered by the usual two Allison 250-C20 turboshaft engines. Fitment of the new powerplants has apparently been responsible for delays with the remaining 44, the final 21 of which – designated AS 555AN – will be able to mount a central 20-mm cannon and a T-100 sight, together with MATRA Mistral AAMs for anti-helicopter missions.

Dauphin goes to sea

On 9 February, St Mandrier-based 23 *Escadrille de Servitude* accepted the first two of three Aérospatiale AS 565M Dauphin 2 helicopters, which will be assigned to the two aircraft-carriers for plane-guard duties. A further 15 of these helicopters will be delivered from late 1991 onwards for replacement of Alouette IIIs in operations from support ships, as well as from the six new *Floréal* frigates under construction.

The CH-47Cs of the Spanish army are being upgraded to CH-47D standard by Boeing Helicopters.

Belgium has announced that four of its six F-16 squadrons will adopt an additional air defence tasking to augment the air defence-dedicated 349 and 350 Escadrilles/Smaldeel. AIM-9M Sidewinders are on order.

NETHERLANDS:

Cuts bite deep

Approval of the 1990 defence budget by Parliament on 30 January confirmed the cuts to be made in the Netherlands armed forces – with the prospect of more to follow if a satisfactory conclusion is reached in the Vienna CFE talks later in 1990. An early casualty has been the proposed follow-on order for 10 General Dynamics F-16 Fighting Falcons, which were to have replaced those transferred to the USA for training late in 1989. A further batch of 18 will also not be ordered, thus limiting procurement to 213, of which 36 are two-seat F-16Bs. As a result, No. 316 Squadron will be unable to replace its NF-5s, and the number of fighters declared by the Netherlands to NATO will be reduced from 162 to 144 – all F-16s in Nos 306, 311, 312, 313, 314, 315, 322 and 323 Squadrons. A requirement for up to 50 attack helicopters also hangs in the balance, even though cheaper alternatives, such as leasing 30 AH-64 Apaches, have been considered.

ITALY:

Harrier II Plus agreement

Final details were worked out between Italy, Spain and the US on development of a radar-equipped version of McDonnell Douglas AV-8B, known as the Harrier II Plus, and were expected to lead to the formal signature of a memorandum of understanding in June. Chosen radar is the Hughes APG-65 (as in the F-18 Hornet). The move ended UK hopes that Italy would buy Sea Harrier FRS.Mk 2s for its new aircraft-carrier, *Giuseppe Garibaldi*. The three nations will share development costs of the new version, with the US Marines taking the last 30-40 of their 328 AV-8B/Ds as II Plus variants, and Spain exchanging its current EAV-8Bs, based on the *Principe de Asturias*, for new-build aircraft. Both European countries are expected to buy an initial dozen II P AV-8s, with an eventual requirement for and two TAV-8Bs for Italy and as many 30 for Spain, if plans are pursued fo second carrier.

PORTUGAL:

New F-16s

Agreement was finally reached in Febru on the supply to Portugal of a squadron General Dynamics F-16 Fighting Falc as part of an arms package proposed m than a year before. The delay was the res of the Força Aérea Portuguesa being l than enthralled with the US offer second-hand F-16A-10s, but it has n been decided to supply new equipment the form of 17 F-16A-15S and th F-16B-15S trainers. Despite their desig tions, the aircraft will be virtua F-16C/Ds, having F100-PW-220 engin provision for AIM-7 Sparrow or AIM- AMRAAM AAMs and Penguin anti-sl missiles, a data transfer unit, radar a meter and the later types of HUD a computer.

SPAIN:

Chinook upgrade

Agreement was reached in January l tween the Spanish army and Boeing-V tol for nine CH-47C Chinooks to upgraded to CH-47D standard for co monality with nine later helicopters op ated by BHelMa 5 at Colmenar Viejo. T first CH-47C was prepared for shipm to BV's Ridley, Philadelphia, plant in Ap and is due to return to Spain in mid-1 after installation of -712 versions of t T55L engine; a new automatic flight co trol system, composite rotor blades a airframe, hydraulics and transmissi strengthening. Completion of the last expected in April 1993.

Five extra VC10 tankers are being converted for the RAF from ex-BA Super VC10s which have been stored at Abingdon. The C.Mk 1 transport fleet is also being given tanking capability with wing pods.

Saab's Gripen is suffering more than its fair share of development problems, highlighted by the crash of the prototype. However, the Flygvapen is continuing full-speed with procurement plans.

SWEDEN:

Gripen presses on

A continued commitment to the JAS 39 Gripen was expressed by the government in January when it requested the JAS Industry Group to quote for a second batch of 110 aircraft to follow the 30 already on order. This was despite a second setback to the programme when it was revealed that the GE/Volvo RM 12 reheated turbofan, which is based on the US-designed F404, was suffering from a serious loss of thrust. However, it is confidently expected that a change to new constructional materials and/or an increase in take-off turbine temperature limits will rectify the problem. Swedish officials believe that the control system software flaws which caused the crash of the prototype Gripen have now been overcome, but a team of experts from the USAF and NASA which visited Sweden late in 1989 is said to harbour slight doubts over the integrity of the re-written software.

SWITZERLAND:

Hornet re-think

Re-appraisal of defence requirements in the light of the sweeping changes in Eastern Europe reached neutral Switzerland during January when parliament re-examined the requirement for 34 McDonnell Douglas Hornets (26 F-18Cs and eight F-18Ds). The aircraft have yet to be formally ordered, and consideration is being given to reducing the order to 24, plus 10 options.

Hawk accepted

Official acceptance took place on 31 January of Switzerland's first BAe Hawk Mk 66, U-1251, following a series of trials undertaken by the GRD since its arrival from the UK on 8 November 1989. A further 19 Hawks are being assembled locally, the first (U-1252) giving a flying display at the acceptance ceremony. Student training on the Hawk, as a replacement for the Vampire, was due to begin on 9 July.

TURKEY:

CN.235 ordered

After a protracted competition in which at least one manufacturer falsely gained the impression of having won, Turkey finally confirmed during January that the Airtech CN.235 would be its future light transport. The Spanish-Indonesian aircraft will be co-produced by TUSAS Aerospace Industries, resulting in all except the first two of 52 aircraft being built in Turkey. A further 20 options are included in the contract on behalf of the local airline, THY. TUSAS Engine Industries will build components for the General Electric CT7-9C powerplant.

SF-260 ordered

In spite of confident claims that the ENAER T-35 Pillán had been chosen by Turkey to end its protracted search for a basic trainer, the SIAI-Marchetti SF-260D emerged victorious late in March, when a contract was signed for 40. The aircraft will be built by Turkish Aircraft Industries at Kayseri, from where six will be delivered in 1990, eight in 1991 and the remaining 26 in the following year. They will replace Beech T-34A Mentors and slightly younger Cessna T-41s at the Gaziemir flying school.

UNITED KINGDOM:

Harrier II trainer order

Having previously intended to convert Harrier T.Mk 4s into T.Mk 6s with night-attack equipment similar to that of the GR.Mk 7, the RAF reversed its course on 28 February when a £200m+ order was announced for 14 new two-seat Harrier IIs, to be designated T.Mk 10. The second-generation aircraft will have construction and handling characteristics identical to those of the 96 single-seater Harriers entering service with Nos 1, 3 and 4 Squadrons, plus No. 233 OCU. Unlike its TAV-8B USMC equivalent, the Harrier T.Mk 10 will be fully operational, with armament capability and the FLIR and night vision equipment of the definitive GR.Mk 7. Final assembly will be on the Harrier line at Dunsfold, using components produced in the UK and USA.

Sea Harrier re-order

Although a re-order for Sea Harriers had long been expected, there was some surprise on 6 March when a follow-on batch was announced of 10 aircraft, not the expected 16. The aircraft, valued at over £10 million each, will be the first built from the outset as Sea Harrier FRS.Mk 2s. Meanwhile, trials were continuing of the two prototype FRS.Mk 2 conversions and preparations made for a re-work of the 37 other Mk 1s surviving from the 57 built.

More VC10 tankers

The death-knell of the RAF's redoubtable fleet of Victor K.Mk 2 aerial tankers was sounded in January when contracts were awarded for conversion of more VC10s to the refuelling role. Work will be undertaken by BAe in conjunction with Flight Refuelling Ltd on two separate programmes, together valued at more than £100 million. The first of these, worth £40 million and meeting Air Staff Requirement 416, involves FRL adding provision for Mk 32 hose-pods under each wing of eight transport VC10s of No. 10 Squadron, amending their designation to C.Mk 1(K). This work will be undertaken at Hurn, Bournemouth, with re-deliveries to begin in spring 1992.

Under ASR 415, BAe's Filton plant will convert five ex-British Airways Super VC10s held in storage at Abingdon for almost a decade. They will become K.Mk 4s with the addition of two Mk 32s beneath the wings and a Mk 17B hose-drum unit in the rear fuselage. Neither the Mk 1(K) nor Mk 4 will be fitted with additional tanks, as were the Mks 2 and 3 tankers currently serving No. 101 Squadron at Brize Norton. The remaining five C.Mk 1s are covered by an option to convert to tanker configuration, but it is expected that No. 10 Squadron's aircraft will continue to fly transport missions for the majority of their time.

More TriStar tankers

Work was also beginning early in the year on conversion to tankers of the first of three ex-Pan Am Lockheed TriStars, two of which are currently used for pure passenger/freight flights. The aircraft are being modified to K.Mk 2 standard Marshall of Cambridge, but will not ceive the additional underfloor fuel ta fitted to the six Mk 1s of No.216 Squad at Brize Norton.

Bloodhound force reduce

In a surprise announcement dur February, the RAF revealed that its forc Bloodhound Mk 2 SAMs was to be c siderably reduced in size, despite only having undergone a refurbishment p gramme for both missiles and their ra control and administrative services. flights of No. 85 Squadron at Bawdsey North Coates are scheduled to close be 31 March 1991, followed by those at Ba ston Heath and Wyton, leaving only W Raynham (HQ) and Wattisham in op ation.

WEST GERMANY:

Safe year

Analysis of accident data showed tha 1989 the West German armed forces joyed their safest year since 1957 (w military aviation was only just beginn after the post-war embargo). There w no fatalities, and only three jet aircraft two helicopters were written off in 400, flying hours. This equates to 0.125 10,000 hours, compared with 0.37 for RAF over the same period. Howe public reaction to flying accidents noise from low-flying aircraft had for the Luftwaffe, especially, to adopt less r istic training profiles.

The RAF responded to an increased number of SAR calls during 1989, Wessex and Sea Kin helicopters launching on 1,306 occasions, supported by 481 RN and Coastguard launches and 75 by Nimrods.

Among the latest crop of aircraft donning military colours is the Saab 340B, a single example of which has been procured for the Swedish royal flight. The local designation is Tp 100.

Left: Four Tornado F.Mk 3s, two GR.Mk 1s and a pair of VC10 tankers deployed to Malaysia to participate in ADEX 90-2. This is one of the No. 5 Sqn F.Mk 3s landing at Butterworth.

Eastern Europe

CZECHOSLOVAKIA:

Soviets to withdraw

Agreement was reached in February between President Havel and the Soviet leader, President Gorbachev, on complete withdrawal of foreign forces from Czech soil by 30 June 1991. Due to depart are regiments of MiG-23/27 'Floggers' at Milovice and Mimon, Su-22 'Fitters' at Sliac and over 200 Mi-8 'Hip' and Mi-24 'Hind' combat helicopters. The Czech government also announced that purchase of MiG-29 'Fulcrums' for its fighter wing at Zatec would be concluded with fewer than half of the planned 40.

HUNGARY:

Skies open

The historic flight of a Canadian Forces CC-130 Hercules over Hungary on 6 January heralded what could be the start of a WarPac-NATO 'Open Skies Policy' – over three and a half decades after it was first proposed by President Eisenhower of the USA. During the three-hour test flight, the aircraft carried no surveillance equipment, and was intended merely to evaluate a principle, soon to be further tested by a Soviet sortie over Canada.

In talks during February, East and West failed to agree upon the fine print of a treaty to permit overflights as a means of confidence-building, but were due to begin a further attempt in April. Points requiring clarification are the types of sensors to be carried, the area which may be covered, the number of flights and whether it should be the surveyor or the surveyed who provides the aircraft. In each of these areas, the USSR is calling for more restrictions than NATO.

SOVIET UNION:

'Hip' shot down

In an occurrence that would scarcely have seemed possible only a few months before, an Aeroflot Mil Mi-8 'Hip' transport helicopter was shot down by ground fire near the village of Chaikent, Soviet Azerbaijan, in mid-January. The Mil was apparently part of a military operation to contain the violence between Azerbaijanis and Armenians settled in the region. A report of 15 January alleged that Soviet helicopters with their identity codes painted over had been firing on Azerbaijani villages.

Right: The French have lifted an embargo on Libyan aircraft held during maintenance. The LAF operates several Mirage variants, including the IIIE.

Below right: Iraq and Jordan are both current Mirage F1 operators, so the establishment of a joint national squadron using the type will pose few problems.

Middle East

EGYPT:

Apaches proposed

A joint offer to Israel and Egypt in January represented the first overseas sale of the McDonnell Douglas AH-64A Apache combat helicopter – even though US military assistance will be footing the bill. Now that US budgetary cuts have curtailed Apache orders at the 807th of 975 formerly proposed for the Army, additional customers are being sought to extend production beyond 1993. Egypt will receive 24 helicopters and 429 Rockwell AGM-114A Hellfire laser-guided anti-tank missiles.

IRAQ:

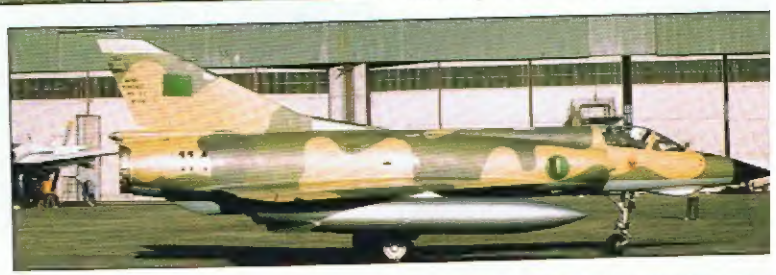
Joint Mirage Squadron

It became known during February that Iraq and Jordan planned to form a joint squadron of Dassault Mirage F1s at the H-3 desert air base in Iraq. This appears to be the natural outcome of a closer collaboration between the two air forces in recent times, typified by Iraqi reconnaissance aircraft using Jordanian airspace for surveillance flights of the Israeli border areas. Contrary to expectations, production of the Dassault Mirage F1 did not end in 1989 with delivery of the 113th (98 F1EQs and 15 two-seat F1BQs) to Iraq, but was continuing into the early part of 1990 to meet an unannounced order for at least 15 more aircraft.

ISRAEL:

Shahal, son of Lavi

First public mention was made in February of a new combat aircraft programme by IAI. Known as Shahal (which is, like Kfir, Aryeh and Lavi, another Hebrew name for a lion), the aircraft is intended to be a simple substitute for the prohibitively expensive Lavi, which was cancelled in 1987. IAI is aiming for a fly-away cost for the Shahal of $6 million, which is towards the upper end of the armed jet trainer price-range and about half the cost of an AMX.



Ethnic violence in Yugoslavia prompted the air force to make shows-of-force over the troubled area. This is a JRV MiG-29 'Fulcrum'.

Southern Asia

INDIA:

Sea Harriers arrive

Deliveries were continuing in the early part of 1990 of further Sea Harrier Mk 51s to the Indian Navy's newly re-formed No. 310 Squadron, which until recently flew the Breguet Alizé ASW aircraft. Some, however, may go to No. 300 Squadron, which has lost two aircraft from its original allocation of six Mk 51s and two Harrier Mk 60s. Total firm commitments cover 23 single-seat Sea Harriers and four Harrier trainers, but India was also considering a conventional fixed-wing carrier aircraft for long-term purchase. It was therefore watching with interest the Soviet MiG-29 'Fulcrum' and Su-27 'Flanker' trials aboard the *Tbilisi* in addition to examining a deck-landing version of the proposed indigenous LCA.

MiG-29 production considered

Plans for local production by HAL of up to 150 MiG-29 'Fulcrums' – known locall the *Baaz* (Eagle) – were again under c sideration with Soviet officials February. The IAF hopes to augment Russian-built MiG-29s delivered to squadrons from December 1986 onw with Indian-built examples, but fears l been expressed that availability of n MiG-29s could imperil the future of LCA light combat aircraft. This proje already under threat from Dassault motion of the Rafale, for whilst the support for the locally-designed figl the IAF is fully aware that previ simpler indigenous aircraft have beer than satisfactory in delivery schedules performance.

PAKISTAN:

More Cobras

Formal notification was given in Wasl ton during January of plans to sup third batch of 10 Bell AH-1F Cobra a helicopters to Pakistan's Army Avi Corps.

Far East

JAPAN:

FS-X agreement reached with US

Having caused delays of up to 16 months, the wrangle between the US and Japan over technology transfer associated with the FS-X fighter appeared to have been resolved in February. The FS-X, which is based on the General Dynamics F-16 Fighting Falcon, was due to fly in 1993 and enter service four years later, but this now seems an impossible schedule to be met. There is still room for further disputes, however, as the US continues to refuse Japan access to the software source codes for the F-16's digital flight control system and radar fire-control.

End of line for KV-107

Long out of production in the USA, where it is known as the H-46, the Vertol 107 twin-rotor helicopter bowed out in Japan during February when Kawasaki delivered the 140th and last licence-produced KV-107. Manufacture has comprised mainly the KV-107IIA-3 minesweeper, A-4 troop/cargo transport and A-5 SAR version for the Maritime, Ground and Air Self-Defence Forces, a few for civilian use and 18 delivered to Saudi Arabia in SAR and fire-fighting guise. At the same time, however, Boeing-Vertol was considering returning the H-46 to production in upgraded form as a partial substitute for the cancelled V-22 Osprey tilt-rotor aircraft required by the US forces.

SOUTH KOREA:

Hawk ordered; Tornado considered

A South Korean order was confirmed in February for 20 BAe Hawk Srs 60 advanced jet trainers to be delivered in 1992-93 as a possible lead-in to licensed production of up to 80 more. BAe is also attempting to sell up to 50 Panavia Tornados to the Koreans, but is competing against its West German partner, MBB. The reason is that the RoKAF requires the majority of these aircraft to be configured for electronic combat and reconnaissance and, whereas BAe is offering an adaptation of the RAF's GR.Mk 1A, MBB has on its production line the fully optimised Tornado ECR. Both firms, however, are being challenged by Grumman and its EA-6B Prowler, which has only recently been given permission to seek export orders.

MALAYSIA:

RAF deploys for exercise

Reportedly close to placing an order for 12 Panavia Tornado IDS variants, Malaysia had the opportunity to assess the aircraft in its own environment when two GR.Mk 1s of No. 27 Squadron were deployed to Butterworth in March. Accompanied by four F.Mk 3 interceptors of No. 5 Squadron and two VC10 K.Mk 2 tankers, the RAF contingent visited the Far East to participate in the Five Power (Australia, Malaysia, New Zealand, Singapore and UK) ADEX 90-2 air defence exercise between 13 and 16 March. This was the RAF's largest deployment to the peninsula for an exercise since the UK withdrew from the area in 1971.

A Republic of Singapore Air Force F-16B on test. Now that pilot training has been completed, the RSAF has formed its first operational squadron, No. 140. The F-16s have replaced Hunters in the air defence role.

SINGAPORE:

F-16s commission

Having received the first of its four General Dynamics F-16A Fighting Falcons and four F-16B trainers in the USA in February 1988, the RSAF commissioned No. 140 Squadron at Tengah exactly two years later, following the completion of training in the USA. The eight aircraft replace No. 140's veteran HS Hunters, which are to be sold. Also out of service are the last 16 BAC Strikemaster armed jet trainers, which were recently sold to an Australian dealer.

VIETNAM:

Soviets depart

A scaling-down of the Soviet presence at Cam Ranh – formerly a major US base – was announced in Moscow during January. The Foreign Ministry confirmed the departure of 14 MiG-23 'Floggers' and part of a squadron of Tu-16 'Badgers', up to 10 of which would remain for a short time before also returning home. Some six Tu-142 'Bears' remained for maritime surveillance.

Africa

ANGOLA:

MiGs and Mils in action

UNITA guerrillas claimed the destruction of three Angolan MiG-23 'Flogger' attack aircraft and five Mil 'Hind' combat helicopters during February as government forces mounted an intensive attack on the rebel stronghold of Mavinga. Although forced to retreat on 2 February, UNITA claimed to have re-taken the town four days later. The 'Floggers' were among 14 of the type brought up from Lubango to Menongue-Cuito for the offensive, whilst the 'Hinds' were given by some sources as the latest Mi-35P 'Hind-F' type. Regular use was made of both aircraft types in the Mavinga attack, said UNITA. Also destroyed, on 30 January, was an Mi-17 'Hip-H' utility helicopter. Later, on 27 March, a civil CASA C.212 Aviocar light transport of TAAG crashed in central Angola, killing all 25 aboard, UNITA claiming to have shot it down.

BOPHUTHATSWANA:

Pilot training

Local training of Defence Force Air Wing pilots began in Bophuthatswana early in 1990, following official commissioning at Mafeking on 1 February of a single Pilatus PC-7 turboprop trainer.

ETHIOPIA:

US vetos Kfirs

US rights over the General Electric J79 turbojet fitted to the IAI Kfir allowed Washington to warn Israel that it would not permit the reported purchase by Ethiopia of this combat aircraft. Unconfirmed allegations appeared in the press during March to the effect that the Marxist regime in Ethiopia was negotiating with Israel for combat aircraft with which to continue its civil war.

SOUTH AFRICA:

Four squadrons to go

As a result of revised defence requirements, the SAAF is to undergo a significant reduction in size during 1990, according to details published in January. Southern Air Command is to be reduced to a skeleton organisation, its base at Port Elizabeth closed, and two of its squadrons disbanded. These will be No. 27 Squadron, with Piaggio P.166S inshore surveillance aircraft, and No. 25 Squadron with C-47s, also in the maritime role. No. 88 MFS, the maritime OCU, will disappear. The SAAF intends to dispose of the P.166s, although the C-47s will be passed to 35 Squadron and updated with avionics and surveillance systems.

Additionally, the Canberra bomber is to be withdrawn from N Squadron, the Super Frelon and Wasp copter fleets phased out, the 35 C4M l liaison aircraft given early retirement 20 Alouette IIIs withdrawn from N Squadron. No. 15 Squadron at Du will get Pumas to replace its Frelons, is probable that No. 41 Squadron wi survive the loss of its Kudus. The S expects few, if any, redundancies to r as so many of its staff have left for ci employment at higher rates of pay there are ample vacancies for staff fro disbanded squadrons.

Also to go are Nos 107 (Hoedspruit the all-female 114 (Zwartkop) Squac of the Air Commando force, compr civilians and their own private aircra at the disposal of the government i emergency. In the SAAF, 'Comman used in its correct, Afrikaans-lang meaning of a 'duration only' volunte

North Americ

CANADA:

Sea King update

As the result of delays with the EH programme, which is unlikely to resu the first squadron becoming operat with 12 of these shipboard helico before 1998, Canada announced ear 1990 that the veteran Sikorsky CH-12 Kings would receive yet a further up this time to CH-124B standard. Aut sation has been given for the first six versions to go ahead, for delivery 1991 onwards, with passive (in pla active) dipping sonar, new MAD eq ment, acoustic processor, analogue ta navigation equipment, directional c mand-activated sonobuoy transmitte an extra UHF radio. Similar modific of the remaining 27 or so CH-124A HS-423, HS-443 and HT-406 is exp to follow.

South America

ARGENTINA:

CBA-123 ordered

Not completely unexpected was the 15 February announcement that the Fuerza Aérea Argentina has placed an order for 20 CBA-123 light transport aircraft being jointly developed by EMBRAER of Brazil and the local firm of FAMA. The prototype of this essentially civilian aircraft is due to fly later in 1990.

Uprated Pampa

Trials were under way early in the year of two armed versions of the FAMA Pampa jet trainer prior to a retrofit programme being undertaken on the 12 aircraft already in service at El Plumerillo with IV Brigada Aérea. These will receive a HUD and other improved avionics, plus four wing pylons for a total of 2,557 lb (1160 kg) of stores and an underfuselage 30-mm cannon developed in Argentina. Later aircraft are expected to adopt the higher-powered Garrett TFE731-3G turbofan of 4,500 lb st (20.0 kN), which will allow them to carry 3,748 lb (1700 kg) of ordnance.

Seasprite order?

It was revealed in March that six Kaman SH-2F Seasprite helicopters would be almost immediately delivered to the Argentine navy for operations aboard MEKO 140 frigates. These helicopters effectively replace the Westland Lynx batch embargoed at the start of the Falklands war with the UK in April 1982, Argentina subsequently selling to Denmark the one Lynx surviving from two delivered earlier. Also in March, the breach between the two former belligerents was closed when Argentina and the UK resumed diplomatic relations.

CHILE:

Israel to upgrade F-5s

Having at one time planned to sell its 12 Northrop F-5E Tiger IIs and three F-5F trainers because of a US spares embargo, Chile revealed in February that it is to modernise the aircraft. Improved support is expected from Washington following the appointment of a civilian government, but it is Israel that will conduct the F-5 improvements. By early 1990, a prototype conversion was in Israel, equipped with avionics from the abandoned IAI Lavi fighter programme, including Elta EL/M-2032B pulse-Doppler radar with look-down capability, a laser designator, integrated RWR/jammer/chaff-flare electronic warfare suite, new INS, air data computer and provision for Python 3 AAMs and Nimrod laser-guided ASMs. The aircraft, known as the F-5 Plus, also has a completely revised cockpit including HUD, HOTAS controls and multi-function displays.

Helicopter trials begin

Following its maiden flight in November 1989, the prototype Cardoen C.206L combat helicopter conversion of the Bell 206L LongRanger was taken to Fort Worth, in the US, for certification trials under FAA rules to be conducted by Global Technologies. This would appear to confirm a change in marketing emphasis to civilian types of duty, such as spraying, power-line inspection and policing, but further reports have linked the helicopter with plans for sales to Iraq, where the C.206L would be armed with Chinese anti-tank missiles.

International

EH.101

Cost questions

A 'disturbing' 28 per cent increase in the estimated cost of 50 EH.101 Merlin ASW helicopters for the Royal Navy was reported by the UK's Commons Defence Committee in January. Whilst admitting that some of the extra expense was the result of additional requirements by the MoD, the Committee also called for improved management of the programme and the setting of more effective contract incentives. On present estimates, the naval EH.101 will cost £40 million – twice as much as a Tornado – but Westland claims that this will be reduced when development costs are shared among the additional orders expected. A cloud also hands over the RAF's proposed order for 25 EH.101s, as the Army is unable to decide the size of helicopter it requires for battlefield mobility. In some quarters, it was being suggested that a mixture of Westland-built Black Hawks and more Chinooks would be the best option.

Tigre/Tiger:

Westland joins in

Following soon after a recommendatio by the Commons Defence Committee i London that the Army Air Corps shoul purchase up to 125 McDonnell Dougl AH-64 Apache attack helicopters, Wes land's February agreement to collabora with Eurocopter in promoting the Tigr Tiger for UK use caught observers by su prise. However, the move is seen as pla ing Westland in prime position whichev helicopter is chosen to meet the British r quirement, as it is already tied in wit McDonnell and the four-nation A 12 Tonal consortium.

Eurocopter's proposal is the more in viting, as it promises a 22 per cent pro gramme share and 100 per cent offsets. I the case of the AH-64, some compone manufacture and straightforwar assembly of complete helicopters would b all that was on offer. Tonal's position wa less than secure as the contenders move towards the mid-1990 deadline at whic the list of competing helicopters would b reduced to two.

The Aérospatiale Panther is being offered to the US Army. The type has enhanced protection with the widespread use of composites. Fuselage side outriggers are fitted for the carriage of weapons.

Left: India is planning to licence-build the MiG-29. This example wears a special scheme for dissimilar air combat training.

Below: This 'warty' BAC One-Eleven is being used by Northrop for YF-23 systems integration.

North America

UNITED STATES

Panther 800 helicopter promoted

Aérospatiale and LTV are teamed up to offer the US Army a light tactical helicopter based on the SA 365M Dauphin (Dolphin) already serving (as the HH-65A) with the Coast Guard but powered by LHTEC T800 engines. The two firms are also working on re-engining a single Coast Guard HH-65A with two T800s to serve as a flight demonstrator.

A 20-month flight test programme for the re-engined HH-65A is scheduled to begin in November 1990. LHTEC, or Light Helicopter Turbine Engine Co., an Allison-Garrett partnership, hopes the HH-65A T800 configuration will be a candidate for eventual retrofit of the entire Coast Guard fleet. The Coast Guard, while severely constrained in its ability to fund a retrofit programme, is interested because of unsatisfactory performance by the LTS 101 turboshaft engines in its fleet of 96 Dolphins.

SR-71 breaks world speed records

Despite being officially withdrawn from operational service with the Air Force during late November 1989, the SR-71 continues to be in the headlines with 64-17972 establishing four distance/speed records on 6 March 1990 while on a delivery flight from Beale AFB to a museum on the East Coast. The Blackbird, crewed by pilot Lt Col Ed Yeilding and RSO Lt Col Joe Vida, set a new world record for the 2,300-mile journey between Los Angeles and Washington in a staggering 64 minutes and five seconds at an average speed of 2,153 mph.

The SR-71 departed Beale AFB shortly before dawn and rendezvoused with a KC-135Q over the Pacific Ocean, where it refuelled before accelerating through the electronic timing 'gate' to the north of Los Angeles at 6 a.m. Pacific Daylight Time, creating a discernable sonic boom. At shortly after 10 a.m. Eastern Standard Time, 17972 passed through the second timing gate above Washington, where it decelerated prior to performing a flypast and landing at Dulles International Airport. 17972 has spent the last few years of its career assigned to Lockheed at Palmdale as the company test and evaluation airframe, displaying a white skunk motif on the fin.

In the course of establishing the Los Angeles to Washington record, 17972 set three additional new timings consisting of 2,112 mph between the West and East coasts a distance of 2,404 miles, which it completed in 68 minutes 17 seconds; 2,181 mph between Kansas City, Kansas, and Washington, a distance of 942 miles in 25 minutes 55 seconds; and, lastly, 2,242 mph for the 311 miles between St Louis, Missouri, and Cincinnati, Ohio, in eight minutes 20 seconds. The new record for the Los Angeles to Washington journey was completed in almost a quarter of the time for the previous one set by a Learjet in 1983 of four hours 12 minutes!

17972 was delivered to Dulles Airport, where it was accepted in a ceremony by the National Air and Space Museum (NASM) at the Smithsonian Institute. The SR-71 will initially be placed in storage by NASM pending the decision to create a new museum extension building, possibly at Dulles Airport. Four other SR-71s were delivered to locations during February and March for display as gate guards or exhibits in museums including 64-17951 to Edwards AFB, California (this being redesignated as a YF-12C serial 60-6937 with NASA between 1971 and 1978 when it was placed in storage at Palmdale), 17958 to Robins AFB, Georgia, 17960 at Castle AFB, California, 17963 at Beale AFB, 17964 with the SAC museum at Offutt AFB, Nebraska, and 17975 to March AFB, California, 17976 for the Air Force Museum being flown to nearby Wright Patterson AFB, Ohio, and 17979 to Lackland AFB, Texas.

When the retirement order was issued, SR-71B 17956, the original trainer aircraft with a raised rear cockpit, was undergoing a major overhaul with Lockheed at Palmdale and has been placed in flyable storage at Palmdale along with 17962 and 17968. These aircraft will be maintained in a state of readiness so that they can be returned to service within a matter of weeks if necessary. NASA will be receiving three SR-71A models, serials 64-17967, 17971 and 17980 for an unspecified project while a similar number will be held as a spares source. The other trainer aircraft SR-71C 17981 was operational with the 9th SRW at Beale AFB and has reportedly been offered for sale, although it is believed to be in storage along with 19755, 17959, 17961 and 17973 at either Beale or Palmdale.

Eleven of these SR-71s were assembled together on the flight line outside the individual aircraft barns at Beale AFB during late January for a unique gathering prior to them being relocated to museums. All had the serial presented in small red digits on the vertical stabiliser and lacked national insignia, except SR-71C 17981, which was still displaying a full-colour star and bar, 'US Air Force' in white along the fuselage aft of the cockpit, and the serial in white.

The official retirement ceremony for the SR-71 was held at Beale AFB on 25 January, and attended by senior SAC and Lockheed's Advanced Development Projects section, which is better known as the 'Skunk Works'.

Formerly flown by Det. 6, 2762nd Logistics Squadron at Palmdale, California, the record-breaking SR-71A 64-17972 wore the Lockheed 'Skunk Works' and Air Force Logistics Command badges on the fin.

Joint Stars European debut

The US Air Force/US Army Joint Surveillance and Target Attack Radar System (Joint STARS), which is housed aboard the Boeing E-8A, a modified 707-320 airframe, made its European debut during February 1990. The primary purpose of the visit was to evaluate the 25-ft sideways-looking radar, which is housed beneath the forward fuselage, in the changeable European climate rather than the stable Florida climate where it normally operates. The prototype E-8A serial N770JS arrived at Mildenhall from Melbourne, Florida, on 19 February in company with 4950th Test Wing NC-141A StarLifter 61-2775, and both left for Lajes and home eight days later. During its stay Joint STARS flew three seven/eight-hour missions and is believed to have performed an additional mission on the flight to Lajes.

The prime contractor for the Joint STARS project is Grumman's Melbourne Systems Division, who are responsible for the installation and testing of the Norden multi-mode radar as well as co-ordin the host of other contractors provi hardware and carrying out modificat The Electronics Systems Division (E with headquarters at Hanscom AFB, sachusetts, is overseeing the progra on behalf of the Air Force.

The primary duty of Joint STARS detect stationary military vehicles a track slow moving armour such as over the battlefield while operatin comparative safety some distance fro forward edge. The E-8 employs both thetic aperture radar (SAR) and Do systems to hunt for its targets an transmit information to either Arm Air Force ground stations via Joint Ta Information Distribution System (JT JTIDS can also be employed to dire force fighters against armoured t acquired by the E-8.

Two E-8As are being employed to uate the Joint STARS programme N770JS and N8411 allocated USAF s 86-0416 and 0417 respectively. The ci identities are being used while the a are assigned to the contractor and w re-serialled once they are handed o the Air Force.

US budget changes

Details of the changes, disbandment closures effecting the fiscal year defence budget were announced b Bush administration on 29 January fo ing a review carried out by Secret Defense Richard Cheney. Primary a these changes are to Air Force Lo Command (AFLC) and Air Force Sy Command (AFSC), which are to ce decision-making process for the ac tion of new products and will instea vide only a supporting role. The c designed to achieve an overall two p decrease in Air Force expenditure, corresponding reduction of 15,000 p nel, while the Army and Navy antic two and one per cent cut respec Details of the changes that affect t Force are presented within their resp Commands:

An SR-71A arrives at March AFB, California, for delivery to the base museum. In the background are the museum's Lockheed U-2 and KC-10/ KC-135 tankers from the resident 22nd Air Refueling Wing.

Military Aviation Review

The Bell/Boeing V-22 (above) is continuing to fight for its future in the face of funding difficulties. To demonstrate the capability of the tilt-rotor, the earlier XV-15 (right) performed in front of the Capitol.

Air Force Reserve

AFRes is to continue its modernisation programme with the acquisition of additional equipment. The 711th SOS at Duke Field, FL, is to receive nine AC-130Hs from 16th SOS in 1992, permitting the retirement of their elderly AC-130As. The 815th WRS at Keesler AFB, MS, will gain six extra WC-130E/Hs from the 53rd WRS by late 1990, thereby taking over the 'Hurricane Hunters' role completely from MAC. The 301st ARS at Homestead AFB, FL, and 304th ARS at Portland IAP, OR, will retire three HH-3Es and five HH-1Hs for four and six MH-60Gs respectively. At March AFB, CA, the 303rd TAS will change to MAS status when it upgrades from eight C-130Bs to 16 C-141Bs, commencing late 1993.

Air National Guard

The 196th TFS at March AFB, CA is to convert from 24 F-4Es to 18 RF-4Cs by late 1990, while the entire reconnaissance Phantom aircrew training task is to be transferred from TAC to the Air National Guard with the 190th TRS at Boise Apt, ID, receiving six extra RF-4Cs to accomplish this task. The remaining ANG changes involve the Fighting Falcon, with the 175th TFS at Sioux Falls, SD, due to receive 18 F-16As in exchange for a similar number of A-7Ds in 1992. The 170th TFS at Springfield, IL, is to increase complement by six F-16As in late 1992, while the 113th TFS at Terre Haute, IN, will receive 18 F-16As in exchange for its F-4Es in mid 1992. The 162nd TFG at Tucson IAP, AZ, will gradually phase out the Corsair II training role with the loss of nine A-7s, imminently followed by a further six in early 1992. The unit will, however, increase F-16 aircrew training for the ANG with the addition of four F-16s in early 1991 and six more the following year.

Military Airlift Command

The 17th MAS 437th MAW at Charleston AFB, SC, will be the first C-17A unit when it receives 13 of the new airlifters in mid-1992 in exchange for 13 C-141Bs. At Altus AFB, OK, the 57th MAS, 443rd MAW will reduce complement by three C-141Bs due to a reduction in training requirements. The 63rd MAW which was due to move from Norton AFB, CA, to nearby March AFB prior to the closure of the former, will no longer be relocated but will deactivate instead, passing its C-141Bs to other units, including the reserves. The 16th SOS at Hurlburt Field, FL, will commence conversion from the AC-130H to the advanced AC-130U 'Spectre' gunship during early 1992.

The 56th ARS at NS Keflavik, Iceland, will switch from three HH-3Es to four MH-60Gs in late 1991, while two new squadrons are to be formed at Nellis AFB, NV, and Misawa AB, Japan, to operate four MH-60Gs each.

Pacific Air Forces

In South Korea the 19th TASS at Suwon AB will transfer to Osan AB by mid-1992, while the RF-4Cs of the 15th TRS at Taegu AB will be retired and the unit deactivated in early 1991, permitting Suwon, Taegu and Kwang-ju, which has no aircraft assigned, to cease USAF operations. These bases will continue to house squadrons of the Republic of Korea Air Force.

Strategic Air Command

The B-52G will continue to be retired, with the 524th BS 379th BW at Wurtsmith AFB, MI, losing six during late 1991, while the 60th BS 43rd BW at Andersen AFB, Guam, is to deactivate shortly following the recent withdrawal of their complement. In addition, the 668th BS 416th BW at Griffiss AFB, NY, will retire its 10 B-52Gs by late 1991 and re-equip with 13 B-52Hs drawn from 5th BW at Minot AFB, ND, 92nd BW at Fairchild AFB, WA, and 410th BW at K.I. Sawyer AFB, MI, who will transfer three each, while the remaining four will be obtained from the 7th BW at Carswell AFB, TX.

The 9th SRW at Beale AFB, CA, will lose six KC-135Qs in late 1991 as a result of the SR-71 fleet being retired. The 11th SG at RAF Fairford, England, will deactivate by early 1991, transferring its KC-135s on temporary duty from the USA to RAF Mildenhall. The 301st ARW at Malmstrom AFB, MT, will gain its second squadron of KC-135Rs commencing in 1991.

Hellenikon AB, Greece, which is located at Athens Airport, will cease to host RC-135s from the USA by late 1991, with the resident 922nd SS being transferred elsewhere. Eaker AFB, AR, which houses the 97th BW, is to be considered for closure by the middle of the decade.

Tactical Air Command

The decline of the RF-4C within TAC is to continue, with the aircrew training role being transferred from the 67th TRW at Bergstrom AFB, TX, to the ANG during early 1990 along with six aircraft. The proposed transfer of six EC-130Hs of 41st ECS from Davis Monthan AFB, AZ, to Bergstrom AFB is to be reviewed as the latter is also to be considered for closure. At Davis Monthan AFB the 355th TTW is to reduce complement by five A-10As, while the 602nd TACW will lose four OA-10As by late 1990. The transfer of the remaining OV-10As of 27th TASS from George AFB, CA, to Davis Monthan AFB will not now take place as the aircraft are to be retired instead.

The 46 F-117As and eight T-38As of 37th TFW will move from Tonopah AFS, NV, to Holloman AFB, NM, during late 1992 in order to reduce operating costs and permit the former to become a satellite of Nellis AFB during Red Flag exercises. The 479th TTW with its four squadrons of AT-38Bs are to vacate Holloman AFB prior to the arrival of the F-117s, with the wing deactivating and the Talons transferred to other units. This move will almost certainly see the discontinuation of the 'Lead-In Fighter Programme'.

At Luke AFB, AZ, the 58th TTW is to reduce strength by nine F-16s and the 405th TTW is to lose 19 F-15As by early 1991 as part of a reduction in fighter training. The 56th TTW at MacDill AFB, FL, will lose 15 F-16Cs early in 1991, while the 64th and 65th AS at Nellis AFB will disband by late 1990 following the withdrawal of 24 F-16Cs in the aggressor role. Six F-16Cs are to be retained at Nellis AFB along with a small number of adversary specialists to be the Red Force during Red Flag operations. The plan to establish an adversary squadron at Tyndall AFB, FL, with the 325th TTW will not now proceed. Myrtle Beach AFB, SC, is to be evaluated for closure although no announcement has been made concerning the future of the three squadrons of A-10As assigned to the 354th TFW.

United States Air Forces in Europe

Zweibrücken AB, West Germany, is to close by early 1994, with the 18 C-23A Sherpas of 10th MAS being relocated elsewhere. The RF-4Cs of the 26th TRW will probably be retired in conjunction with other as yet unspecified units, as part of the Conventional Forces in Europe (CFE) treaty between the USA and the Soviet Union. The 38th TMW at Wueshheim, West Germany, 487th TMW at Comiso, Italy, and 501st TMW at Greenham Common, UK, are to deactivate during 1991 following the removal of all cruise missiles and associated equipment back to the USA for destruction.

The 48th TFW at Lakenheath, UK, is reduce complement by six F-111Fs in ea 1992, although this will probably be lit more than a paper exercise, with the a craft involved being lost through attriti rather than being physically retired.

Maiden flight of new 'Ai Force One'

The first Boeing VC-25A, which w eventually become the new presiden aircraft 'Air Force One', made its maid flight on 26 January from the compan facility at Wichita, Kansas. The first flig took place considerably later th originally planned due to unforeseen tec nical problems involving the wiring their complex communications equipm as well as additional fire safety syste now required to be fitted to all new p senger aircraft under FAA rules. The a craft has now commenced the first o two-stage test programme involving installation of instruments to meas flight. These instruments will be remov before commencement of the sec stage, which will evaluate its air refuell characteristics. Lastly, the distinct white, blue and gold exterior paint sche will be applied before delivery.

VC-25A 82-8000 is now due for livery at the end of September 1990 lowed by second aircraft 82-9000 wh will follow in June 1991. These will join 89th MAW at Andrews AFB, MD, placing a pair of C-137Cs which will be legated to routine VIP duties.

T-45 shifted to St Louis

Production of the Douglas T-45A G hawk trainer for the US Navy, carr capable version of the British Aerosp Hawk, has been shifted from Doug Long Beach, California, facility McDonnell in St Louis, Missouri, in or to 'free up' the California plant to har increased orders for MD-11 and MD-8(commercial jetliners.

Moving in the face of increased requirements for commercial airliner construction capacity, the McDonnell Douglas/BAe T-45A Goshawks for the US Navy are now being built at St Louis instead of Long Beach.

After six new-build aircraft, SH-2G production will centre around the reworking of current service SH-2Fs. The conversion entails re-engining with uprated powerplants and numerous other equipment updates.

SH-2G Super Seasprite delivered

The first Kaman SH-2G Super Seasprite anti-submarine helicopter was delivered to the US Navy in a 'fly-off' ceremony on 21 March 1990 at Bloomfield, Connecticut. The SH-2G, capable of operating from about 129 surface ships, is an upgrade of the SH-2F helicopter which is part of the LAMPS (Light Airborne Multipurpose System) Mk I system.

The SH-2G is powered by two 1,690-shp General Electric T700-GE-401/1401C engines offering about 340 more shaft horsepower than the SH-2F now serving with the Fleet. Improvements to the helicopter include a sonobuoy data processing system, composite rotor blades, and IR (infra-red) target detection system.

Typically launched from a frigate or cruiser, the SH-2G can patrol 35 miles (56 km) from its mother ship for 90 minutes, as compared with a 72-minute duration for the SH-2F. The manufacturer claims a 20 per cent improvement in fuel consumption. The SH-2G can carry two Mk 46 or Mk 50 lightweight torpedoes or Penguin air-to-surface missiles. Provisions exist for AIM-7 Sparrow and AIM-9 Sidewinder missiles, though these probably would not be carried on routine missions.

The SH-2G programme began in 1985 when Secretary of the Navy John Lehman told a Senate panel that it would be more cost-effective to upgrade an operational helicopter than to develop a new one to increase anti-submarine capabilities.

The aircraft rolled out on 21 March was bureau number 161653, originally built as an SH-2F, flown in developmental work as the sole YSH-2G and first flown in SH-2G configuration on 28 December 1989. The Navy is acquiring six new-build SH-2Gs, and additional aircraft at the rate of six per year will be rebuilt from existing SH-2Fs.

The SH-2G will go simultaneously to active and Reserve forces. HSL-33 'Sea Snakes' at NAS North Island, California, will be the first active Navy unit to operate the type, followed by Reserve squadrons HSL-74 'Demon Elves' (NAS Weymouth, Massachusetts). HSL-84 'Thunderbolts' (North Island) and HSL-94 'Titans' (NAS Willow Grove, Pennsylvania).

Three V-22s flown

All three flyable examples of the Bell/Boeing V-22 Osprey were in the air simultaneously for the first time on 24 February 1990, in a show of progress with the tilt-rotor aircraft Defense Secretary Dick Cheney intends to cancel. Aircraft nos 1 and 2 flew at Bell's facility in Fort Worth, Texas, while aircraft no. 4 flew at Boeing's Wilmington, Delaware location. Aircraft no. 3, being readied by Bell, had not yet made its first flight at the time.

Controversy swirls around the V-22, which promises to introduce a new independence from airfields for various missions: the aircraft enjoys more support in Congress than in the Pentagon. Only the Marine Corps remains steadfast in its support for its version, the MV-22.

Commandant of the Marine Corps General Alfred Gray told Congressional leaders just before the three-at-a-time flight that there is no inexpensive alternative to the MV-22 Osprey for the Marines' medium-lift needs. The 26-year-old Vertol CH-46 Sea Knight tandem-rotor helicopter can no longer safely carry Marine troops into a modern battlefield, Gray testified. He said that the VTOL (vertical take-off and landing) capability of the Osprey is necessary for future Marine operations.

In separate testimony before the House of Representatives, Marine Corps Lt Gen Charles H. Pitman told listeners that the V-22 Osprey offers mobility previously unavailable to the Corps.

In a related move aimed at salvaging the V-22 and to dramatise its potential, Bell/Boeing demonstrated the XV-15 tilt-rotor demonstrator in front of the Capitol Building in Washington on 25 April 1990.

With increased thrust available from its two F110 engines and increas capability thanks to an equipment update, the F-14D variant has brou the Tomcat into the 1990s. This is the first production machine.

F-14D rolled out

On 23 March 1990, Grumman rolled out the first of 37 new production F-14D Tomcat fighters, which have improved radar, software and other electronics changes as compared with F-14A and F-14A+ aircraft now in service. The F-14D has General Electric F110-GE-400 engines, Hughes APG-71 radar, General Electric infra-red search and track system, and digital instruments.

The ceremony followed the 9 February 1990 first flight of a production F-14D. Four airframes, all converted F-14As, have been carrying out a flight test programme for the D model in which 600 flights and more than 1,000 hours have been logged.

Production of the Tomcat will end with delivery of the 37th 'new build' F-14D in 1993, although 300 to 400 existing F-14A airframes will be converted to F-14D standard.

T-1A Jayhawk chosen

The Beech T-1A Jayhawk is to beco new training aircraft for US Air multi-engine pilots. The Pe announced on 21 February 1990 t TTTS (Tanker/Transport Tr System) will be the McDonnell Do Beech entry, using a modification Beech 400A business jet. The syste chosen over competitors from C Lear and Sabreliner.

The US Air Force has prev employed a universal pilot training s under which all pilots train in the C T-37 and Northrop T-38 before beg with the aircraft they will fly in the s Under the TTTS scheme, those scheduled for for types such as K C-141 or C-5 will 'break off' after training and move to the T-1A Jay without ever flying the T-38. The s will save wear on the ageing fleet of for which no replacement is now pla The Strategic Air Command has de to include in TTTS bomber pilots wi wants to fly the T-38 before proceed B-52 or B-1B.

The initial contract for $8,893,171 production of the first batch of aircr options for a total of 211 T-1A aircr 1997. USAF Air Training Commar begin employing the T-1A in Sept 1992. The T-1A designation has prev been applied to the Lockheed T2V Star, which is no longer in service.

Beech reports that its success wi TTTS contract has indirectly contr to 32 new civilian purchases of the 400A aircraft, which is itself a vers the Mitsubishi MU-300 Diamon configured for the US Air Forc Beechjet will have cockpit seating fo dent who will fly in the left-hand s instructor in the right-hand seat, third crew seat for another studer mediately behind.

McDonnell Douglas will ser primary contractor for the systen Beech providing the aircraft and Qu the TTTS flight simulators.

TBILISI

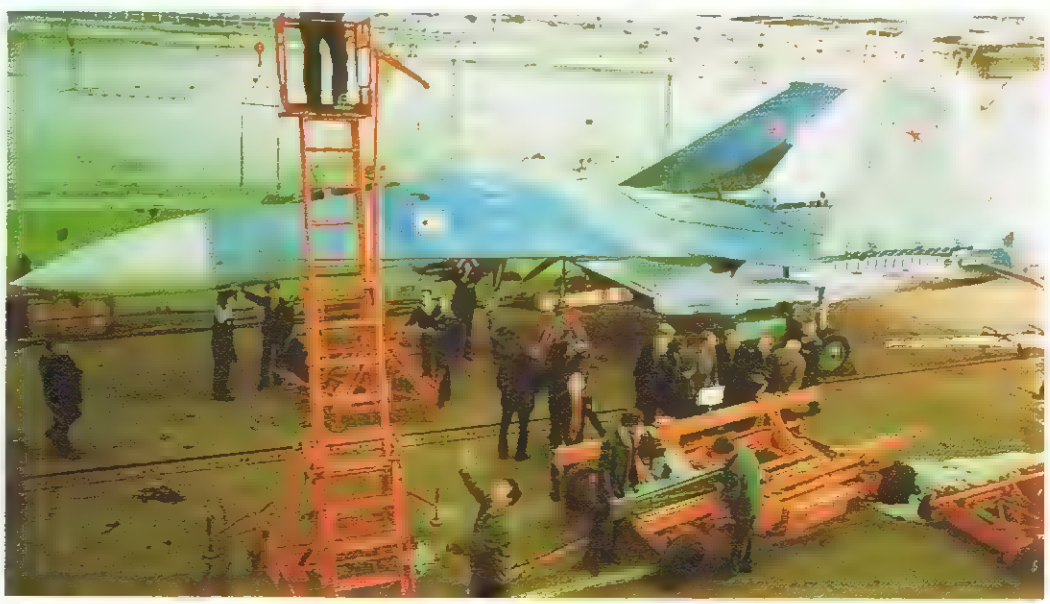
The Soviet Supercarrier

The Soviet AV-MF has a long and distinguished history. Originally formed in 1913 as the air service of the Tsarist navy, it fought with distinction in World War I and its Red successor played a similarly important role in the revolution of 1917, when it dropped one-third of the bomb tonnage delivered by Red air forces.

But thereafter the Red navy became something of a poor relation, and the air service suffered from a limited budget and low status. Russia had a 'white water' or coastal defence strategy, and the navy limited its seaborne aviation activities to seaplane tenders. After World War II, Stalin toyed with the idea of creating a 'blue water', ocean-going navy to counter the US and British fleets, but he died before plans could be formulated, let alone put into effect.

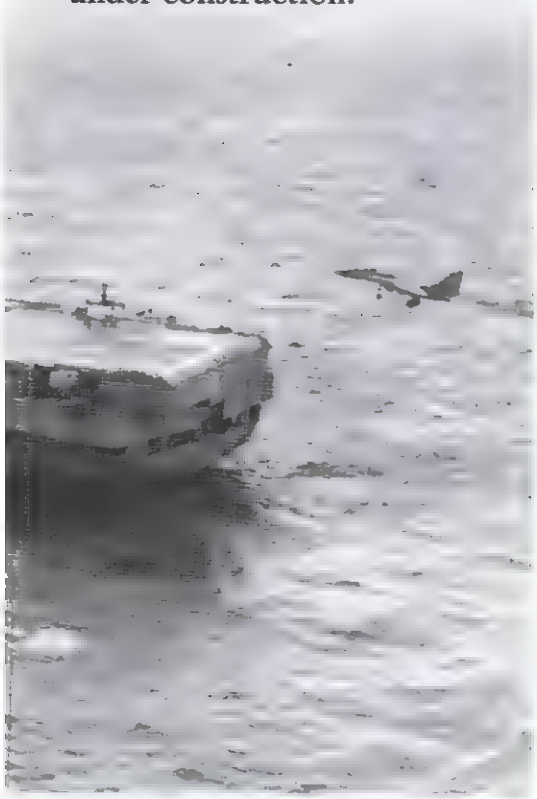
Khrushchev drew away from this idea, and directed his newly appointed naval commander-in-chief, Admiral Gorshkov, to concentrate his attentions on the defence of the homeland and co-operation with ground forces. As a result of this directive the navy lost its sizeable interceptor force to the IA-PVO, and received only second-hand bombers and antiquated flying-boats for long-range patrol, anti-shipping and reconnaissance duties: more advanced dedicated aircraft such as the Beriev Be-10 'Mallow' failed to secure funding.

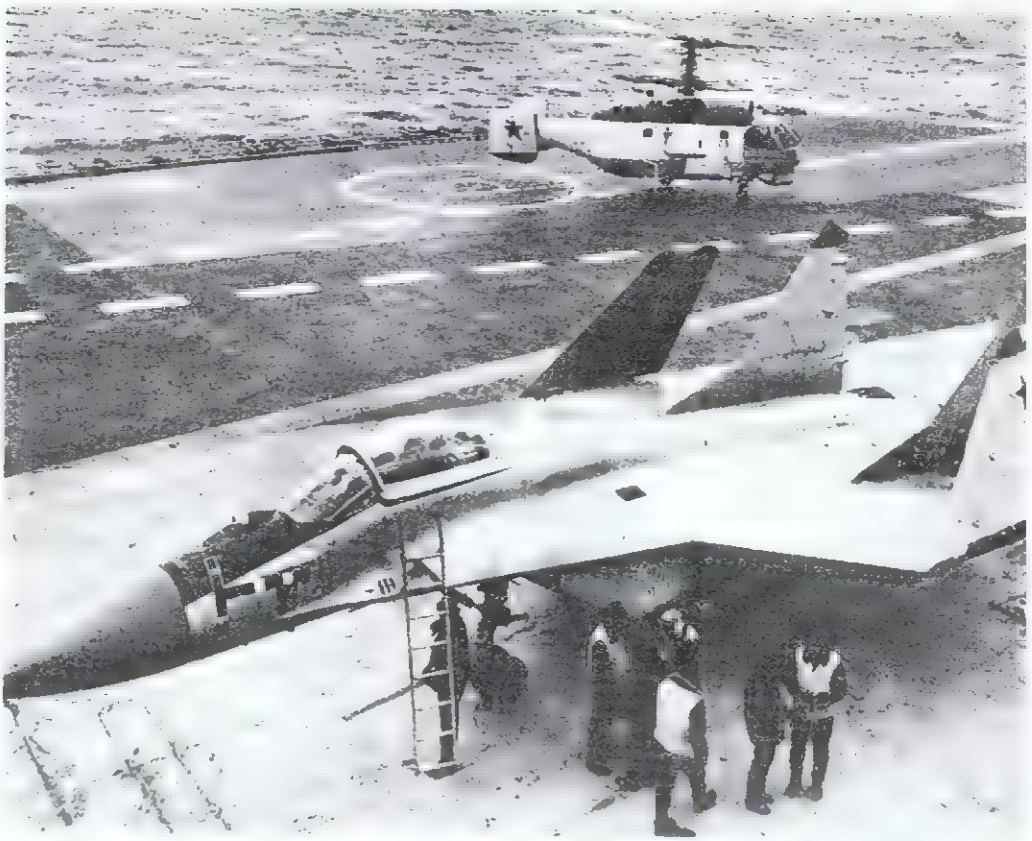
Despite doubts about the wisdom of this policy generated by the Soviet Union's inability to intervene at Suez and during the Cuban missile crisis, the 'white water' strategy remained largely unchanged until after the departure of Khrushchev in 1968. During the mid-1960s, Soviet naval



Tbilisi: *The Soviet Supercarri*

With the operational deployment of the new carrier *Tbilisi* expected very soon, the Soviet navy is the newest member of the 'supercarrier club', joining the USA and France. Recent trials in the Black Sea gave a fascinating glimpse of the Soviet navy's latest and most powerful capital ship. Two sister ships are already under construction.





Left: An Aeroflot Mil Mi-8 'Hip' hovers next to the Tbilisi as a MiG-29 approaches the ramp for a touch-and-go. Soviet navy Kamov Ka-27 'Helix' helicopters also performed plane-guard duties during the trials, and one of these can be seen parked on the deck.

Above: Engineers cluster around one of the navalised 'Fulcrums' used during the deck landing trials on Tbilisi. The sealed overwing intake louvres and modified IRST ball of the naval 'Fulcrum' are clearly visible on this aircraft.

aviation did receive one important boost, in the form of the introduction of the Kamov Ka-25 'Hormone' anti-submarine helicopter.

Trials using a Ka-10 'Hat' had been undertaken on board the cruiser *Maxim Gorky* in 1950, and small numbers of Kamov Ka-15 'Hen' helicopters were procured and used in piecemeal fashion during the early 1960s, but the use of the Ka-25 was much more important. Initially deployed singly on the new 'Kresta' class cruisers, the 'Hormone' went on to serve with the air wing of the *Moskva* when it appeared in 1967. *Moskva*, and its sister ship the *Leningrad*, were anti-submarine cruisers, and while they marked an increase in 'blue water' ASW capability they did not signal any real move away from the navy's prevailing 'defence of the homeland' role.

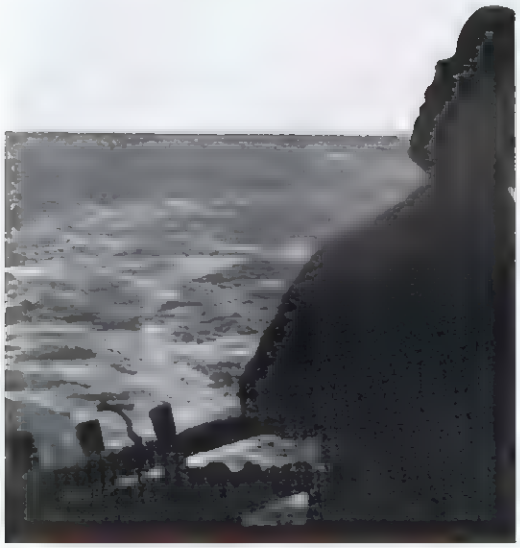
The removal of Khrushchev generated a vigorous debate on the need for true aircraft-carriers within the naval high command. By 1970 they were laying down the keels of the first of the 'Kiev' class of 'aircraft-carrying cruisers' at Nikolaiev, but these, like the two 'Moskvas', were ASW carriers, albeit with a limited (peacetime) intervention role using the Yak-38 'Forger'. T latter would no doubt be useful for certain roles wartime (e.g. countering NATO maritime pat aircraft), but is short-ranged, poorly equipp and has a tiny warload and no all-weather cap bility, which severely limits the ability of the c rier to operate in hostile airspace.

The debate continued and even intensifie with senior Soviet admirals (most notably R Admiral Pushkin) vigorously arguing the case

Left: This pristine Su-27, seen on the hangar deck of the Tbilisi, has been described as a navalised 'Flanker'. However, it lacks an IRST and many of the features of the other 'Flanker' photographed on Tbilisi, so it may be an engineering mock-up or instructional airframe.

Right: Tbilisi's bows are dominated by a steep, curving ski-jump as originally designed for the Harrier family of V/STOL strike fighters. On Tbilisi this will be used by conventional aircraft instead of a steam catapult. Yak-38 or -41 V/STOL fighters might also form part of the air wing.

Tbilisi: *The Soviet Supercarrier*



larger, American-style nuclear-powered carriers, often quoting fictional 'foreign analysts' to disguise their commitment to unpopular and unofficial arguments.

These larger carriers would, it was claimed, allow surface units to operate within the range of enemy land-based aircraft by establishing local air superiority (essential for assault landing operations), would be able to screen friendly SSBNs (ballistic missile-carrying submarines), and counter enemy ones, and would be an excellent means of power projection and 'flag waving'. Large nuclear carriers were claimed to be cheaper to run and more effective than smaller, cheaper-built carriers, providing better air defence than V/STOL carriers and better AEW cover than scattered radar picket ships.

Mystery carrier

In 1984, after a series of rumours, Western satellite photographs revealed a large carrier (estimated to be some 75,000 tons, and believed to be nuclear-powered) under construction at Nikolaiev, and Western experts estimated that sea trials of the vessel, predicted to be the *Kremlin*, would begin during 1988-9. At the same time, it was revealed that various aircraft types (including the Su-25 'Frogfoot', the MiG-29 'Fulcrum' and the Su-27 'Flanker') had been undergoing trials Saki, a naval airfield on the Black Sea which v equipped with dummy carrier flight decks, cluding arrester gear, catapults and even s jumps.

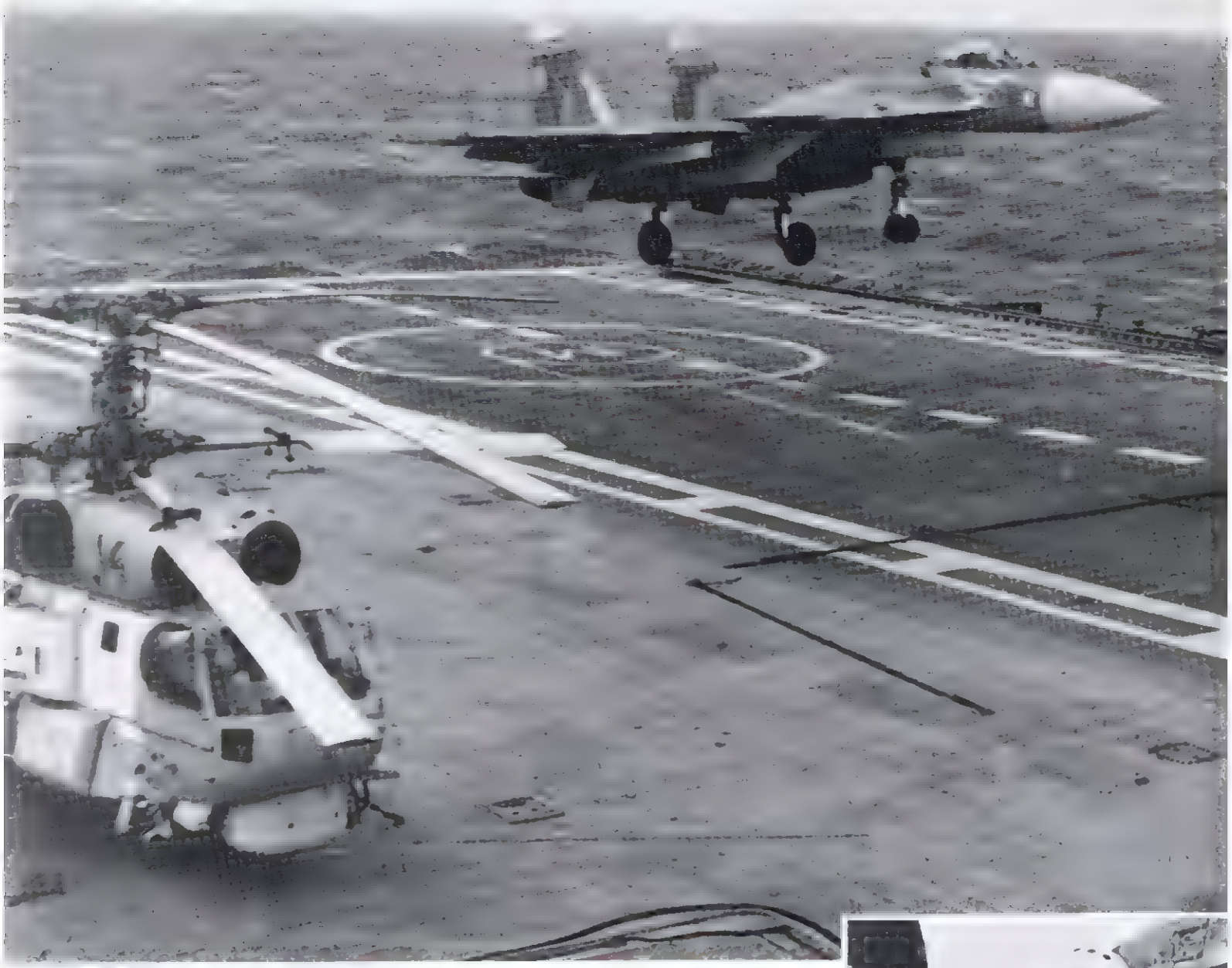
Construction of the carrier clearly presented major problems, and the Soviet shipbuilders k to the West's estimated timetable, although appearance of the vessel on sea trials brou about a rapid re-assessment of its displacement 65,000 tons! This smaller-than-anticipated s did not mean that the ship was any less importa however, and Soviet press reports heralded new vessel (named *Tbilisi*, and not *Kremlin*) as 'Flagship of the Soviet Navy'. It was immediat apparent that much of the new carrier's equ ment was identical to that carried by *Baku*, the l of the four 'Kievs', perhaps indicating that latter vessel had been used as a trials vessel for new ship.

Radar and communications

Four huge phased arrays serve the 'Skywat radar, while aerials for 'Top Plate' air surveilla radar and 'Top Mesh' sea surveillance radar also prominently visible, carried back to back top of the 'Cylinder Blanc' EW antenna. 'St Pair' (or possibly 'Strut Curve') surface sea

Left: The navalised Sukhoi Su-27 'Flanker-B2' is seen on finals. This aircraft features canard foreplanes, folding wings and a shortened inter-nacelle bullet fairing. It has been (wrongly) described as the T-10-39 (the 39th Sukhoi T-10, e.g. the 39th prototype 'Flanker').

Below: Victor Pugachev brings the Su-27 in ov the arrester wires to land on the deck of the Tbilisi for the first time, passing one of the plane-guard Kamovs. Seconds later he had arrived, taking an OK 2-wire! Canard foreplan give the Su-27 much improved take-off and landing performance and low-speed handling characteristics.



Above: Before his first landing Pugachev flew a series of dummy approaches, getting lower and lower before overshooting. These culminated in a series of touch-and-goes, the last with a 50-ft deck roll, before the first arrested landing. The huge fighter displayed impeccable carrier landing characteristics.

***Right: Victor Pugachev, one of the Sukhoi OKB's senior test pilots, is best known for his record-breaking flights in the 'P-42' and for his astonishing dynamic deceleration manoeuvre, the 'Cobra', as seen at Paris and Asian Aerospace displays. He is seen here after becoming the first pilot to land aboard the* Tbilisi.**

radar is carried at the front and back of the island, which also houses 'Big Ball' satellite communications aerials and a dome-shaped radome for what may be 'Punch Bowl', the satellite targetting system previously associated with the SS-N-12 anti-ship missile. Various ECM, ESM and gun-laying systems are also present, but photographs so far released do not allow these to be definitely identified.

Missile capacity

The *Tbilisi* packs a mighty punch even without her air wing. There appear to be 12 vertical launch tubes for the 340-nautical mile range SS-N-19 'Shipwreck' anti-ship missiles fore and aft of the island, with four groups of six launch tubes for the SA-N-9 SAM on each 'corner' of the deck. These contain a total of 192 missiles.

A new close-in weapons system appears to be fitted on each side, ahead of the angled deck, along with a number of remotely-controlled gun turrets, each containing a 30-mm six-barrel Gatling gun. Two 10-barrelled 350-mm RBU anti-submarine rocket launchers are carried on each side of the stern and pictures of the second ship, *Riga*, on the slipway appear to show a hull-mounted active sonar housing, indicating that the ship probably has a significant ASW capability in its own right.

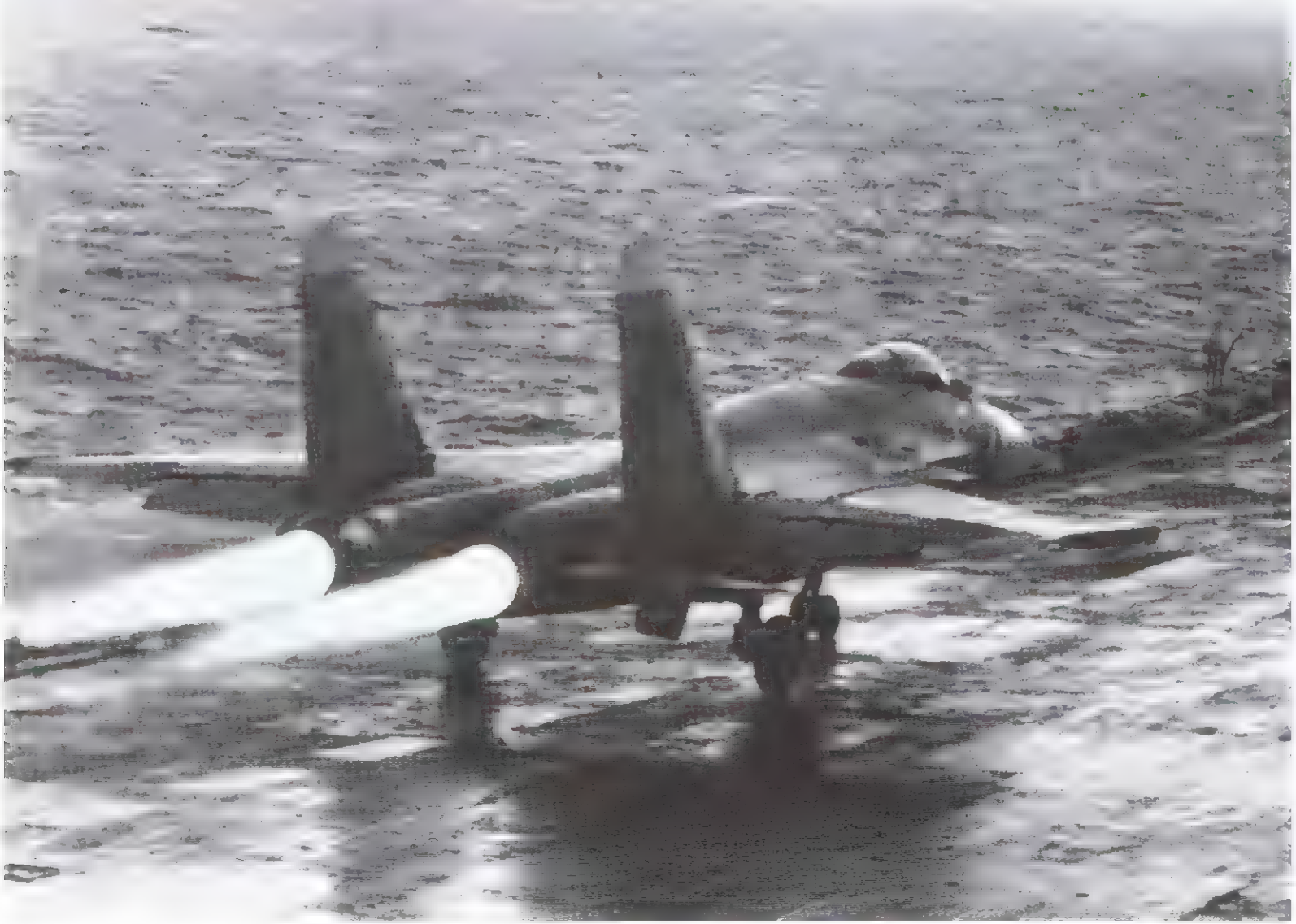
It is now known that the new ship was laid down at Nikolaiev in January 1983, and launched in 1985 as the first of at least three ships referred to by the Soviets as 'heavy aircraft cruisers'. Interestingly, the first two ships will be conventionally powered, with engines producing some 200,000 shp and giving a top speed of more than 30 kt. After sea trials it will become the flagship of the Northern Fleet, under Captain Victor Yarygin, a high flyer who previously commanded a 'Sverdlov' class 'gun cruiser'.

The new ship will play a vital part in countering US and NATO navies and air arms operating in the Norwegian Sea, supporting Soviet land, sea and sub-surface forces. With air superiority, the Soviet navy could be confident of securing the entire Norwegian Sea, down to the Greenlan Iceland-UK gap, safeguarding its SSBNs a weakening NATO's vulnerable Northern Flan The next two ships will be the *Riga* and the larg nuclear-powered, 75,000 ton *Ulyanovsk*. Sov unwillingness to use the term 'aircraft-carrier' c be explained by the 1936 Montreux Conventio which strictly controls the passage of capital shi through the Dardanelles.

Traditional layout

Soviet designation aside, the *Tbilisi* is unm takeably an aircraft-carrier in the classical moul with an angled flight deck, four arrester wi (each 14 metres apart), and two deck-edge elev tors (possibly with a third elevator inboard of t island). Unusually, *Tbilisi* has a 12° ski jump

Using the ski-jump, and in clean configuration, the 'Flanker' demonstrated a take-off distance of less than 100 metres. Fully laden, 180 metres were required.



Left: The Sukhoi Su-27 (just visible going off the end of the angled deck) 'bolters' after a missed approach. The naval Su-27 has already been code-named 'Flanker-B2' by NATO's Air Standards Co-ordinating Committee.

place of the more usual steam catapults. Behind this there are traditional-looking jet-blast deflectors to prevent blast damage to aircraft and equipment further down the deck. These are combined with unusual mechanical restrainers, which allow an aircraft to be run up to full power before launch.

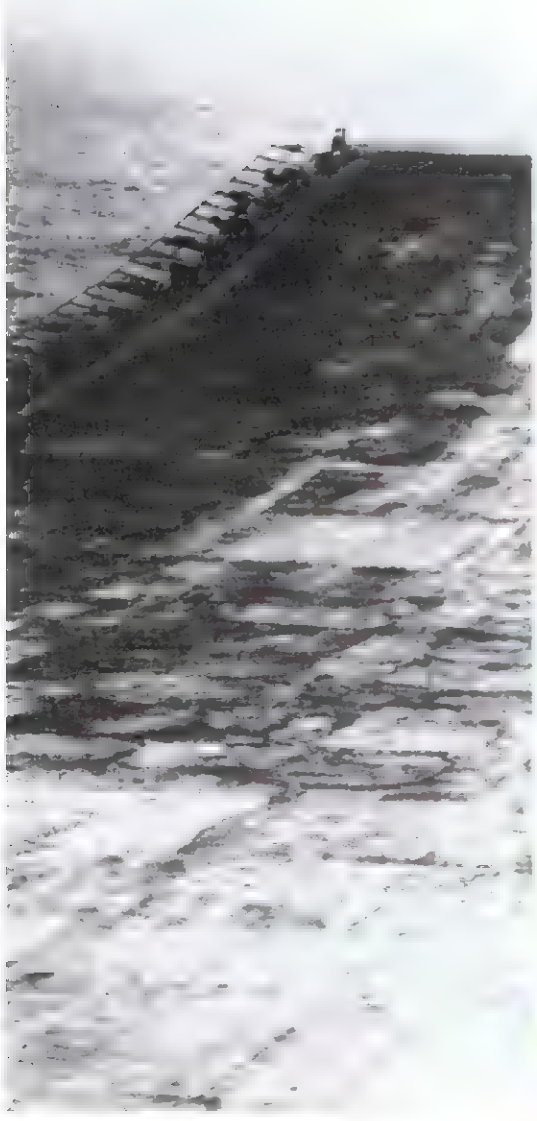
Catapults may be added to *Tbilisi* at a later date, and will be fitted to *Riga* and *Ulyanovsk*. They would almost certainly be essential in order to launch a heavily-laden strike aircraft like any naval Su-24 'Fencer', or a large AEW aircraft like the An-74 'Madcap'.

The presence of a ski-jump does not mean that *Tbilisi* will deploy with an air group consisting solely of helicopters and V/STOL aircraft, however. Various sources, from the Novosti Press Agency to senior Soviet admirals, have stated that the 60-aircraft air wing will include CTOL (Conventional Take Off and Landing) aircraft. Novosti's statement was the least ambiguous: "The first Soviet aircraft-carrying cruisers of the 'Kiev' type only carried V/STOL fighter bombers. *Tbilisi*, though, will carry aircraft of a different class: fighter jets meant to counter enemy aviation." Such statements were apparently confirmed by the carrier qualification tests that began on 21 November 1989, involving naval versions of the MiG-29 'Fulcrum' and Su-27 'Flanker'.

The first fixed-wing aircraft to land on the *Tbilisi* was a canard-equipped, folding-winged version of the Sukhoi Su-27 'Flanker' (wrongly said to be the T-10-39), carrying the code '39' on the nose. Veteran Sukhoi OKB test pilot Victor Pugachev made several low passes over the deck at reducing speeds, before making a number of touch-and-go landings. Finally, after a 'touch and go' with a deck roll of 50 metres, Pugachev landed, taking the number 2 wire.

A second Su-27 has also been seen on the *Tbilisi*, during trials. This aircraft lacked canards and the familiar IRST, but was equipped with folding wings, and carried the AV-MF flag on the nose. Both aircraft were fitted with twin nosewheels in place of the single nosewheel fitted to land-based 'Flankers', and both lack the prominent inter-engine bullet fairing.

Which configuration might represent the production navalised Su-27 is uncertain, although



Above: The crew of the Kamov Ka-27 'Helix' brief before the deck landing trials. The Kamov Ka-27PS, code-named 'Helix-D' by NATO, is a dedicated search and rescue and plane guard helicopter.

canard foreplanes would seem to be very useful reducing approach speeds and improving take-o performance. The Su-27 demonstrated take-o distances of 100 metres (clean) and 180 metr (fully laden) using the ski-jump, going off the e of the ramp at 140-160 km/h. Approach speeds 220-240 km/h were also demonstrated. O navalised 'Flanker' prototype was lost duri trials on the dummy carrier deck at the naval a field at Saki, and this may have been the cana and vectoring nozzle-equipped T-10-24.

The second aircraft to land on the *Tbilisi*, a the first fixed-wing aircraft to be launched, wa single-seat Mikoyan MiG-29 'Fulcrum', flown OKB test pilot Takhtar Aubikirov. The bureau deputy chief test pilot, Anatoly Kvotchur, w

Below: The Ka-27PS is equipped with a power rescue winch above the rear cabin door, and various other items of rescue equipment. The Ka-27PS is deployed aboard the 'Kiev' and 'Moskva' class cruisers.

Tbilisi: *The Soviet Supercarrier*

Above: Two MiG-29s were involved in trials on board the* Tbilisi. *The second aircraft, coded '18', was flown by senior Mikoyan test pilot Anatoly Kvotchur. Like the first aircraft, it wore prominent camera interpretation marks on the nose and tail.

Above: The first MiG-29 sits on the* Tbilisi *deck, wings folded. The IRST ball ahead of the windscreen is changed, and may now house an imaging infra-red. Bulged wingtips house new ESM equipment.

also involved in the trials. The Mikoyan OKB claims to have spent 10 years developing the naval version of the MiG-29, and is quietly confident of attracting an export order from India, who would presumably use the aircraft on its planned new carrier.

Two MiG-29s were flown onto the *Tbilisi*, coded '311' and '18'. Both aircraft lacked the air intake doors and auxiliary overwing air intakes of other MiG-29s, and had folding wings, arrester hooks, and strengthened undercarriages for carrier operation. They both had modified IRST balls ahead of their windscreens, which appeared to house some kind of imaging infra-red system. One of the aircraft lacked the fin leading edge extensions, housing upward-firing chaff and flare dispensers, fitted to most single-seat MiG-29s. This may indicate that the aircraft was rebuilt from an early production machine, or that the chaff dispensers are not felt to be necessary in the naval variant. The naval MiG-29 is claimed to have an inflight-refuelling capability.

Other aircraft involved in the trials included a Sukhoi Su-25UT, flown by Igor Botinsev and Alexander Krutov. The Su-25 is unlikely to form a part of any air wing, but has obvious potential as a carrier-capable training aircraft in the same mould as the McDonnell Douglas/British Aerospace T-45 Goshawk, although Sukhoi themselves are not happy with using tandem two-seaters on carriers, and are said to be developing a 'side-by-side' Su-27UB for carrier use.

Air power projection

The *Tbilisi* is unlikely to need a dedicated attack aircraft, since its main role will be air power projection and since the MiG-29 can successfully perform ground attack and interdiction missions. In any event, *Tbilisi* is believed to have a significant anti-ship capability using the SS-N-19 'Shipwreck' missile. ASW operations will probably be left to other ships in the Task Force, carrying dedicated helicopters. If the V/STOL Yak-38 'Forger' or the new Yak-41 are deployed on *Tbilisi* they will probably form only an interim component of the air wing, pending the availability of sufficient 'Fulcrums' and 'Flankers'.

Although we may see a mixed V/STOL CTOL Air Wing on the *Tbilisi* initially, the fi definitive unit will consist mainly of the Su 'Flanker' and MiG-29 'Fulcrum' aircraft. In or to maintain four standing CAPs (two high, t low) each of two aircraft, for a short period, t at least two 12-aircraft squadrons of figh would be needed. These would need to be loca on each side of the main threat axis, at least nautical miles from the ship, in order to de stand-off weapons. Additional aircraft would needed if these four CAPs were going to be ma tained for any length of time.

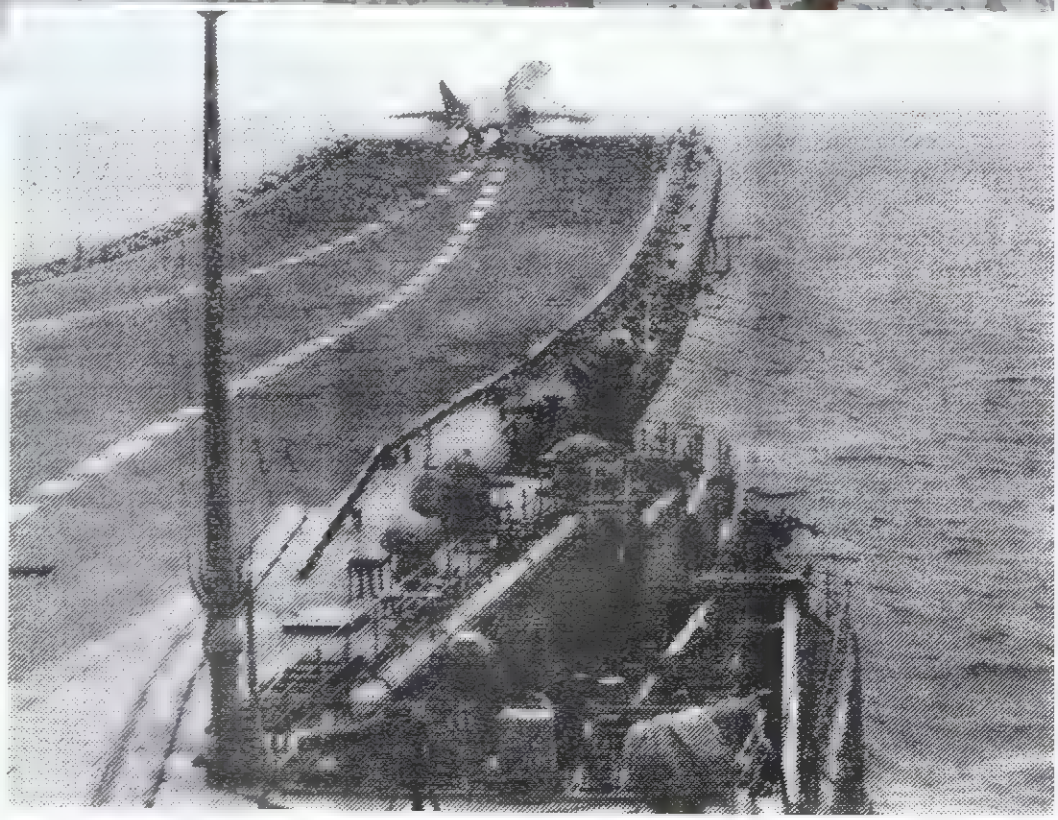
It would seem likely that *Tbilisi* would emb two squadrons of Su-27s in the primary defence role, with two or three MiG-29 squ rons fulfilling a similar role to that of the F/A-1 US Navy CVWs, acting as extra air defence as when needed, or as light attack aircraft. For ma mum flexibility, an air wing of four or even f MiG-29 squadrons could be embarked.

SAR cover for the trials was provided by a f of Kamov Ka-27 'Helix-Ds' and an Aeroflot Mi-8 'Hip'. Fortunately, these were not need and the MiG-29 and Su-27 performed faultles although the Kamov Ka-27 would be a lik

Above: The absence of overwing fin extension fences, and their associated upward-firing chaff/flare dispensers on the naval MiG-29, may indicate that the aircraft was converted from an early production aircraft, which also lacked these features.

component of any air wing, for SAR, COD and other duties. The Ka-29 'Helix-D' infantry assault helicopter and the new Ka-41 'Hokum' attack helicopter are also possible candidates for inclusion in the Tbilisi air wing.

The Soviet navy clearly expects both aircraft to be able to operate from the ship with a worthwhile weapons load, and a 'buddy' refuelling store is under development for carriage by the Su-27. Then the Soviet fleet will have a genuine air defence capability, enabling it to conduct operations within range of enemy territory or aircraft-carriers.

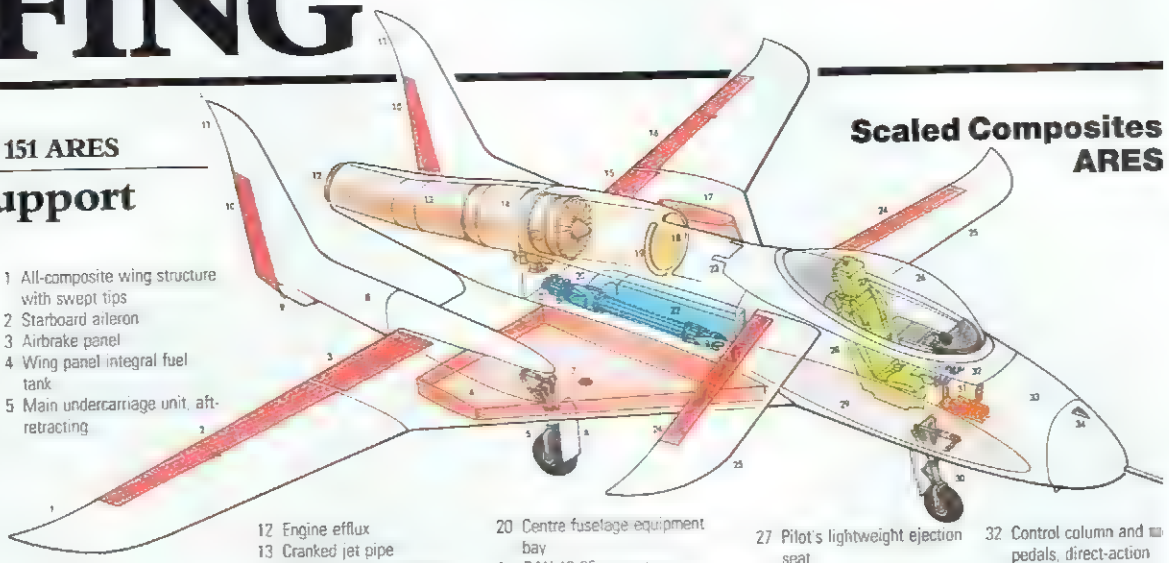


Takhtar Aubikirov flew the MiG-29 off Tbilisi's ski-jump to become the first to take off from Russia's first conventional aircraft-carrier. The MiG-29, with its excellent performance and versatility, seems likely to form a part of any air wing.

BRIEFING

Scaled Composites Rutan Model 151 ARES

High Tech Close Support



1 All-composite wing structure with swept tips
2 Starboard aileron
3 Airbrake panel
4 Wing panel integral fuel tank
5 Main undercarriage unit, aft-retracting
6 Mainwheel leg door
7 Fuel filler cap
8 Tailboom
9 Tail bumper
10 Rudders
11 Twin composite fins with swept tips
12 Engine efflux
13 Cranked jet pipe
14 Pratt & Whitney Canada JT15D-5 turbofan engine with electronic fuel control
15 Port airbrake panel
16 Port aileron
17 Port wing integral fuel tank
18 Engine air intake, offset port
19 Boundary layer bleed duct
20 Centre fuselage equipment bay
21 GAU-12 25-mm rotary cannon (mounted on aircraft CG)
22 Ammunition magazine
23 Canopy hinge point
24 Elevators
25 Fixed canard foreplanes
26 Single-piece canopy, upward-hinging
27 Pilot's lightweight ejection seat
28 Space provision for avionics equipment bay
29 Cannon muzzle reinforced blast trough
30 Nose undercarriage, forward-retracting
31 Dashboard
32 Control column and pedals, direct-action mechanical flight control system
33 All-composite fuselage structure
34 Fresh air intake
35 Test instrumentation boom

Scaled Composites Inc, jointly owned by Bert Rutan and Wyman-Gordon of Worcester, Massachusetts, now manufactures composite aerospace structures for Wyman-Gordon and provides research and development facilities for advanced aeronautical concepts, frequently producing advanced prototypes for other manufacturers or under government contract. Scaled Composites contributed to the NASA AD-1 oblique wing research aircraft, and built a 62 per cent scale prototype of an Advanced Technology Tactical Transport aircraft to fill the void between large helicopters and the C-130.

Canard foreplanes have been a distinguishing feature of Rutan's designs since his earliest home-builds, and remain a feature of his latest aircraft, the Model 151 ARES. Designed as a private venture, with no outside funding, the aircraft was intended to demonstrate what could be done using current technology to provide a low-cost alternative to the prohibitively expensive warplanes currently used for a number of roles, including anti-helicopter (for which the ARES demonstrator is sized), close air support, forward air control, tactical reconnaissance, border patrol and special operations.

Modern materials and structural techniques are used to integrate a large gun into a small airframe, without compromising structural strength, survivability or range. Simplicity is used as the key to durability, affordability and ease of maintenance, and great stress is laid on the ability to operate from short, soft airfields.

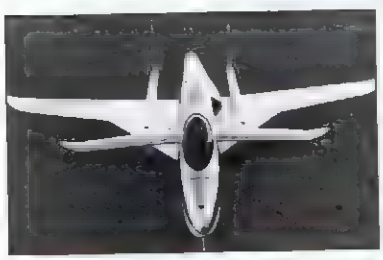
ARES is an acronym for Agile Responsive Effective Support, and is also the name of the Greek god of war. The demonstrator is optimised for the anti-helicopter role, in which high speed, exceptional agility, long endurance and the ability to fly nap-of-earth are essential. The aircraft is powered by a Pratt & Whitney Canada JT15D-5 turbofan, and sufficient internal fuel is available for a range of 1,400 nautical miles.

The aerodynamic design of the ARES, coupled with its high thrust, gives the aircraft excellent performance, with better speed and turning capabilities than current attack helicopter types. Natural aerodynamic stall limiting gives departure free manoeuvring characteristics even at full aft stick deflection, and with no need of electronic control system augmentation.

The demonstrator is armed with a General Electric 25-mm GAU-12/U cannon with 220 rounds of ammunition, and there is provision for a selection of missiles. To protect the engine from gun gas ingestion, the fuselage is not symmetrical. The engine air intake is located on the port side of the fuselage, while the gun is located in the starboard wing root. Gun blast is absorbed by thick composite sandwich structure and the aerodynamic shape of the fuselage shields the canopy and offsets yaw caused by firing.

The entire centre fuselage is an open payload bay some 92 inches long, centred on the CG and accessed through a door on the right-hand sid of the aircraft. This can be used fo weapons carriage, or to give the air craft built-in growth potential, allow ing a two-seat cockpit or heavie armament to be incorporated for us in other roles.

The initial flight test programme to concentrate on flying qualities, per formance and basic systems, and wi include an initial evaluation of th type's suitability as an operational air craft. If these are successful an ope ational fire control system ar avionics will be installed for furth trials in simulated threat enviro ments.



From the front the ARES displays its unique offset engine intake, offering reduced radar reflectivity, and reduced vulnerability to small arms fire, ingested gun gases and FOD.

ARES flies in formation with the Scaled Composites Triumph, both aircraft having similar wing planforms and canard foreplanes.

AMX two-seater

Italo-Brazilian Combat Trainer

Development of a two-seat version of the Italo-Brazilian AMX light attack fighter began in 1987, to meet a joint Italian and Brazilian requirement for a conversion trainer, although it is also hoped that the two-seater might pave the way towards further variants of the aircraft for roles such as night attack, ECR (Electronic Combat and Reconnaissance) and guided weapons control.

A high degree of commonality was built into the two-seater, which has the same external dimensions as the original aircraft. The two-seater features duplicated flight control system and a colour TV head-up display repeater in the rear cockpit. The cockpits are sufficiently stepped to give the occupant of the rear seat the same 18° forward/downward visibility as the man in the front seat. The second cockpit is provided by removing one fuel tank and repositioning the environmental control system, but full operational equipment, including internal guns and the full EW suite, is retained. This gives the two-seater full combat capability, although with a smaller radius of action.

The two-seat prototype was rolled out at Aeritalia's Caselle plant on 25 January 1990 in the presence of General Franco Pisano, Italian air force Chief of Staff, and made its first flight in the capable hands of Commander Nap Bragagnolo, the Aeritalia chief test pilot, on schedule, on 14 March.

Apart from the excitement of flying what he knew to be a new type, he described the flight as being no different from the production test flight of a single-seat AMX that he had flown shortly before. Before flight, the two-seater was cleared to fly over the full flight envelope of the original aircraft, and Bragagnolo flew the aircraft to high speeds and high *g*, noticing no performance penalties by comparison with the single-seater. The flight test programme for the two-seater will involve two Italian and one Brazilian airframe, and in addition to these aircraft five two-seat fuselages were in an advanced stage of construction by January 1990.

Deliveries of the first of 51 production two-seaters for the Italian air force will begin before the end of the year, while the first of Brazil's 15 trainers is to be delivered in mid-1991.

The AMX two-seater is a neat conversion, with only a small loss of performance due to the removal of one fuel tank.

Sikorsky MH-60K

Special Operations Hawk

In an ever-changing geopolitical situation, the requirements for weapon systems to meet new demands are constant. Thus the growing importance of the ability to fight limited wars against guerrilla and Third World enemies, and the greater need for clandestine forces to engage specific targets behind enemy lines, has produced a corresponding need for dedicated Special Operations aircraft, tailored to autonomous, small-scale operations in night and adverse weather conditions.

Helicopters are ideal for this purpose, and the US Air Force has employed versions of the Sikorsky H-3 and H-53 on Special Forces support duties and related combat rescue missions for some years. The most recent type to enter USAF service is the Sikorsky MH-60G Pave Hawk, equipped with forward-looking infrared (FLIR) and inflight-refuelling capability. Following in the wake of Special Forces variants of the McDonnell Douglas 500 and 530, designated AH-6 and MH-6, the US Army is looking to dramatically increase its own heliborne Special Operations capability with the Sikorsky MH-60K.

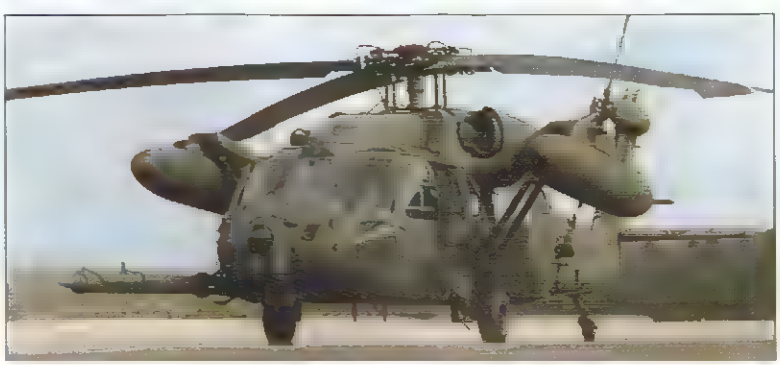
The UH-60 Black Hawk is the standard US Army assault helicopter, so it made sense to use this airframe as the basis for a Special Operations aircraft. Consequently on 26 January 1988, Sikorsky received a US$82.8 million, 38-month contract to develop, build and test a prototype of the MH-60K. Following reviews of the proposal, Sikorsky was then given a long lead-time funding contract for the first 11 production aircraft, set against a requirement for 22 aircraft in all. The first is due to be delivered to the US Army in November 1991, and the service has an option on a further 38 machines.

On 14 March 1990, the prototype was rolled out at Sikorsky's Stratford, Connecticut, plant. As can be seen, this is no ordinary Black Hawk! It is powered by a pair of uprated General Electric T700-GE-701C turboshafts, each developing 1400kW (1,900shp), as opposed to 1151kW (1,560hp) for the early UH-60A aircraft. The Sikorsky 3400 Series Improved Durability Gearbox is fitted. Held on heavily-braced pylons high on each side of the cabin are external fuel tanks of 870.5 litres (230 US gal) each, considerably extending the variant's range. Extending from the lower starboard nose is a long refuelling probe for use with Lockheed HC-130 tankers. Some extra strengthening has been incorporated, and folding stabilator, tiedowns and rotor brake have been inherited from the SH-60 Seahawk to facilitate air transportability. Also thanks to the SH-60 is the MH-60K's Automatic Flight Control System.

While the extra fuel and refuelling allow the MH-60K to undertake long distance penetrations behind enemy lines, it is the avionics suite that allows it to operate safely at night and in appalling weather. Mounted centrally ahead of the nose is a thimble radome for the Texas Instruments AN/APQ-168 terrain-following radar, while below that is a turret for a Hughes AN/AAQ-16 FLIR. These are integrated with cathode-ray tube cockpit displays to allow full nap-of-earth (NOE) terrain-following capability in adverse conditions. At the heart of this integration is the IBM Integrated Avionics Subsystem, which combines navigation, communications and other systems to ease crew workload in high-risk scenarios.

These avionics combine to allow the MH-60K to safely cross the front line and penetrate deep into enemy territory at night using NOE flying, whereupon Special Operations teams can be inserted and retrieved for reconnaissance or special sabotage missions. A winch is mounted in the starboard cabin door for airborne retrieval. The helicopter itself is liberally protected with the latest in defences. Radar, laser and infra-red warning systems are incorporated, together with appropriate countermeasures including flare dispensers scabbed on the tail boom. Strengthened pintle mounts in the doors are for 0.5-in machine-guns to provide suppressive fire, while the helicopter is capable of carrying Stinger missiles for defence against other aircraft.

When the MH-60K enters service, it will be the major Special Operations platform for the US Army, bridging the gap between the small and nimble MH-6s and the larger and less agile MH-47E. Further additions of equipment to mirror advances in opposing weapon systems seem inevitable.



The first MH-60K displays the type's purposeful lines. Note the nose-mounted sensors, refuelling probe and the external tanks.

BRIEFING

Ayres V-1-A Vigilante

Low-Cost Mud-fighter

Not only does the Vigilant feature heavy armament, but it also has full countermeasures. In addition to COIN work, it is applicable to anti-drug operations.

The Ayres Corporation, perhaps the world's leading ag-plane manufacturer, has developed a new light military aircraft, and is currently marketing the machine, designated V-1-A and dubbed Vigilante, to a variety of potential customers. Powered by the 1,376-shp Pratt & Whitney Canada PT6A-65G turboprop, with a quiet Hartzell five-bladed reversible-pitch, fully-feathering propeller, the Vigilante represents a logical step forward from the Turbo Thrush NEDS (Narcotics Eradication Delivery System).

The Turbo Thrush NEDS is used by the US State Department for operations against marijuana and coca growers in a number of countries, including Belize, Guatemala, Colombia and Mexico. These aircraft are unarmed, except for their hopper-full of herbicide/defoliant. They are, however, quite heavily armoured and fly with two pilots, often in the face of hostile ground fire.

From an early date, Ayres could see the aircraft's potential as a military platform, with its excellent short-field, unprepared strip capability, heavy load-carrying capacity, long endurance and excellent performance. (A Turbo Thrush flown by Bill Brodbeck, Ayres Marketing Manager, broke several world time-to-height class records.) The aircraft's simplicity and ruggedness make it easy to maintain in a field environment, and easy to operate in harsh climatic conditions.

The Vigilante has been developed as a result of this experience, with input from the State Department and from the US Army, especially during the Electro Optical Survivability Program, when the aircraft was used as a test platform. The aircraft was chosen largely because of its tubular structure, which means that the skin does not form part of the structural support, and can therefore easily be removed for the installation and removal of equipment. The airframe of the V-1-A has been slightly modified, with a much larger rear cockpit to accommodate the surveillance systems operator. As in the Turbo Thrush NEDS, this retains basic flight instruments and is fitted with dual flying controls.

The V-1-A combines the tried-and-tested, simple and rugged airframe and engine combination of the Turbo Thrush with high technology sensors and weapons for surveillance and a variety of close support missions. In the surveillance role, the Vigilante can carry a number of sensors, including a turret-mounted Honeywell or Lockheed Gimbol/Texas Instruments or Lockheed Gimbol/Kollmorgen FLIR, a Multi-Spectral or Laser Gated low-light television camera and a Honeywell IRLS. Information from two sensors can be displayed on a high resolution video monitor, simultaneously recorded on board on half-inch tape, and relayed via data link in live video or secured frozen imagery to a control centre over 100 miles away. A small display in the front cockpit allows the pilot to see the systems operator is seeing.

The Vigilante has eight under hardpoints and in the close su role these can be fitted with p and standard NATO weapons r The inboard pylons can carry 1,200lb, while the outer three p on each wing can carry up to each. External fuel tanks, .50-cal 7.62-mm or 20-mm gun pods, 5 bombs, 2.75-in rockets, mines, a air missiles and anti-tank missile all be carried by the aircraft, a using a simple sight or a more so ticated head-up display, accordi customer requirements.

The modern battlefield, eve Third World areas, is a hostile p and a variety of defensive sys have been installed in the protot These have included radar and i red warning systems, and countermeasures equipment. Arm protection for the crew and cr components can be provided, an fuel tanks can be made self-sealin full reserve fuel system is also a able. Finally, the aircraft is avai with reduced IR signature paint engine exhaust suppressors.

The idea of a simple aircraft what is now known as LIC (Low tensity Conflict) has not arouse much interest since the 1950s, w the USAF briefly evaluated Fletcher FD-25 Defender. Propon of the aircraft cite a number of world situations where the air could be used to advantage, inclu the Upper Hualanga Valley in P where US Drug Enforcer Agency officials are working with local police against cocaine produc

LANA and YA-7F/A-7 Plus

A-7 improvements

The Vought A-7 Corsair was conservative even before it first flew. Essentially a subsonic development of the supersonic F-8 Crusader, the A-7 was designed as a quick solution to the Navy's VAX requirement for a well equipped, relatively cheap strike fighter able to carry a heavy load, loiter in the target area and hit a point target with pinpoint accuracy. The USAF decided to adopt the Corsair in 1966, as impressed by the evaluation results as it had been with the US Navy's Phantom less than 10 years before.

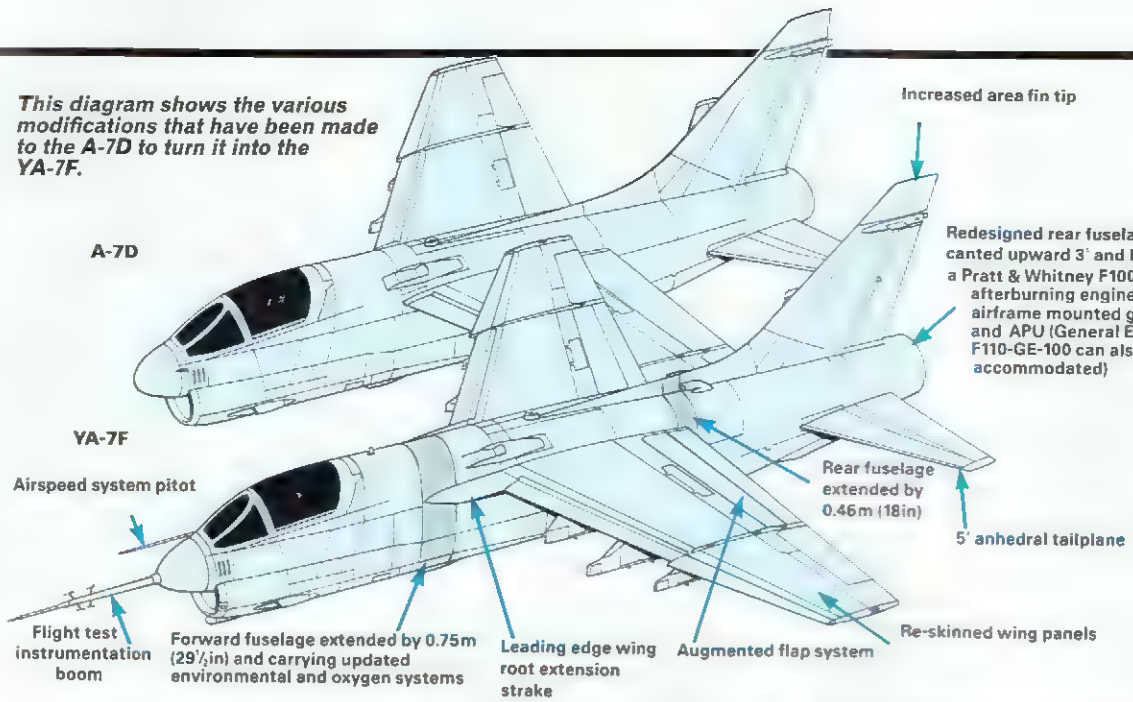
The Corsair was transformed for USAF service, the new A-7D being powered by the Allison TF41-A-1 (a development of the Rolls-Royce Spey) and equipped with a new 20-mm multi-barrel cannon, a new advanced nav/attack system, a head-up display and a laser range-finder. Four hundred and fifty-nine were eventually delivered to the USAF (plus 30 A-7K combat-capable two-seaters) and, from 1981, to the Air National Guard.

The Corsair virtually disappeared from first-line, regular service during the early 1980s, replaced by the A-10A Thunderbolt II, but it remained an important type in the ANG inventory, equipping an eventual total of 14 squadrons, and with important contingency commitments to NATO, Korea and Central Command (Panama). The aircraft also equipped Greek and Portugese air force units and clearly still had a role to play. Vought, however, could see that various updates would considerably enhance operational capability. For export customers, Vought proposed the International Corsair II, based on a stripped A-7B airframe but equipped with modern avionics and night attack sensors and weaponry, and the similar International Corsair III, which was to have been stretched, fitted with a 27,600-lb st afterburning General Electric F110-GE-100 engine, automatic manoeuvring flaps and an all-new digital avionics suite.

In June 1985, the US Air Force issued a Request for Information on interim solutions to its Close Air Support/Battlefield Air Interdiction re-

With its lengthened tailpipe, heightened fin and longer fusela the YA-7F looks uncannily like t Crusader from which the origina A-7 was developed.

quirement, seeing the A-10 as be too vulnerable to survive in modern 'AirLand Battle'. LTV p posed a modernised, supersonic Strikefighter programme, involv the conversion of 396 ANG A-7 and A-7Ks and 96 USN A-7Es. T



This diagram shows the various modifications that have been made to the A-7D to turn it into the YA-7F.

new aircraft was to be powered by the F100-GE-200 engine, and fitted with augmented flaps, wing strakes, new technology leading edge and trailing edge flaps, provision for Maverick and Sidewinder and upgraded avionics, possibly including LANTIRN and automatic terrain-following.

LTV claimed that by comparison with an unmodified A-7D the new aircraft would need 45 per cent less ground roll on take-off, would be more manoeuvrable (able to sustain a 7*g* turn) and much faster (with Mach 1.2 dash capability). The programme was soon scaled down to cover the conversion of 337 former ANG aircraft and the updated A-7 was renamed A-7 Plus. The Air Force gave initial approval to the programme in 1985, and in 1986 Congress allocated $35 million from the FY 1987 budget to full-scale development of the new aircraft.

In the meantime, the Air Force Air Logistics Center at Oklahoma City placed a contract covering the upgrade of 75 (initially 72) A-7Ds and eight A-7Ks with LANA (Low Altitude Night Attack) capability. This involved the provision of a Texas Instruments AAR-49 FLIR, automatic terrain-following capability, new GEC Avionics wide-ang derived from that fitted to th to give round-the-clock, ur weather capability.

The first Corsair with modifications was an A-7K 162nd TFTS, Arizona ANG, made its first post-update fli October 1986. Deliveries beg summer of 1987, initially to t TFG, New Mexico ANG. systems have been provided squadrons.

On 7 May 1987 LTV re formal contract to upgrade tw airframes to A-7 Plus config for evaluation as a solution USAF's CAS/BAI requirem contract specified all the A-7 fighter modifications plus tended tailfin, lift dump spo airframe-mounted accessory self-contained ground opera replacement INS, a GPS HOTAS cockpit, plus full modifications. These were to improve weapons deliver

The first YA-7F arrives at Ed AFB after delivery from Vou plant at Dallas. The two pro conversions are currently undergoing joint LTV/USAF

BRIEFING

Nearly double the original thrust is available thanks to the P&W F100 or GE F110 afterburning jets fitted to the YA-7F. This is the first aircraft under test.

racy, provide genuine all-weather capability, and to improve speed, manoeuvrability and take-off performance.

The fuselage of the A-7 Plus incorporates a stretch of 29.5 inches ahead of the wing and 18 inches aft, providing space for fuel and avionics and improving the fineness ratio of the fuselage. The wings are modified to incorporate strakes (giving a 10 per cent increase in turn rate and improving high AoA performance), spoilers (decreasing ground roll on landing by some 10 per cent), and augmented flaps. These permit slower landing speeds (an eight-knot reduction in approach and touchdown speed) and a consequent 20 per cent reduction in landing roll. They also improve low-speed handling characteristics. Replacement wing skins will be warranted for 4,000 additional flying hours.

The aircraft has a common engine bay, capable of accommodating either the Pratt & Whitney F100-PW-220 or the General Electric F110 actually fitted to the first two prototypes. This virtually doubles the thrust available to approximately 26,000 lb st with afterburning, improving speed, acceleration and manoeuvrability.

The first prototype A-7 Plus made its first flight on 29 November 1989, in the hands of LTV Aircraft Products Group chief test pilot Jim Read. The successful flight lasted one hour 10 minutes, and a number of systems, engine and overall stability checks were carried out under the watchful eye of two chase aircraft, an A-7 and an F-4 from Edwards AFB.

During the one hour 45 minute second flight on 13 December the YA-7F achieved an acceleration from .85 Mach to 1.04 Mach, marking the first supersonic Corsair flight. A second pilot, Jerry Mumfrey, made the third flight on 14 December. After four flights in the hands of company test pilots, the flight test programme transferred from NAS Dallas (adjacent to LTV's Dallas facility) to Edwards AFB for evaluation by a joint USAF/LTV test team.

The test team at Edwards comprises Jim Read and Jerry Mumfrey from LTV and Lt Col Mark Prill and Captain Mark Stone from the US Air Force. Lt Col Prill flew the first test flight from Edwards on 12 January, and since then the aircraft has f intensively, testing cruise perf ance, acceleration, turning perf ance, engine handling and flying ities. In early March the ai underwent inflight-refuelling re- fication trials. Engine shutdown throttle sweeps are being cond across the full range of power se from idle to afterburner at diff altitudes and airspeeds.

The second prototype YA-7F its maiden flight in the hands of Mumfrey on 3 April 1990, m two more flights before he ferri aircraft to Edwards on 6 April. H joined the first prototype and is used in the same flight test gramme which is due to run thr until September 1990.

The second YA-7F lifts off from NAS Dallas during its maiden flight. The figures claimed for the new variant are most impressive compared to the original A-7D.

Atlas XH-2 Rooivalk

South African Attack Chopper

The Atlas Aircraft Corporation was founded in 1963, and initially built only components for licence-assembled foreign designs. UN arms embargoes forced it to become independent of foreign assistance very early, maintaining and overhauling many SAAF aircraft types without any support from the original manufacturers. Independent design capability came more slowly, and the Cheetah upgrade of the Mirage III was largely the result of collaboration with Israel.

During the early 1980s it was decided to concentrate on the design and production of an indigenous armed helicopter, an aircraft capable of being deployed as an attack helicopter in support of highly mobile ground forces. Atlas progressed towards their goal by stages, and did not attempt to build a prototype straight away.

The first step, after establishing maintenance and component manufacturing capabilities for the Puma and Alouette III (in order to maintain the SAAF fleet of these types on an entirely self-sufficient basis), was to build a systems testbed, based on a converted Alouette III airframe, and a contract for such an aircraft was placed by the SAAF in March 1981.

Construction began in January 1983, and the aircraft, known as the Alpha XH-1 (Experimental Helicopter), made its maiden flight on 3 February 1985. The XH-1 provided useful experience and a good way of testing avionics and other systems. In the event of the definitive developed helicopter failing, it would have also provided a possible fall-back option.

Lessons learned from the XH-1 were incorporated into the Beta XTP-1 (Experimental Testbed), which was unveiled in April 1987 after flying during 1986. This aircraft was a converted Puma, with little str alteration beyond a new tailf stub wings (each with four w pylons) but with a compute trolled ventral gun turret conta 20-mm GA-1 cannon (also used XH-1), aimed by a helmet-m sight. A second Puma was also the development programme, l aircraft may not have been cor to XTP-1 standards.

The first stage to a new South African attack helicopter was taken with the Alpha XH-1, based on the Alouette III. This tested gunship systems.

Development of the definitive attack helicopter, the XH-2 Rooivalk (Greater Kestrel) began in 1984. This was based on a Puma dynamic system, but with a new narrow-section fuselage and a weapons system developed during the XTP-1 programme. At one stage Atlas described the new aircraft as "a substantially upgraded Puma with more powerful engines and new locally-designed avionics", but admitted that the aircraft would "hardly be a Puma except in its general configuration".

The extent of the changes made was revealed when the Rooivalk was rolled out at Kempton Park on 15 January 1990, looking every inch an operational machine, with the angular stepped cockpits that have been *de rigueur* for this type of aircraft since the AH-64, advanced electro-optical target acquisition aids in a nose turret, and stub wings mounting six weapons pylons, including wingtip launch rails for the V3B Kukri AAM or the new Darter heat-seek AAM. Underwing pylons can ca podded unguided rockets of f examples of a newly developed bea riding anti-tank missile. The G cannon is swivel-mounted under fuselage, and can be aimed by eit crew member's helmet sight. gunner has a rudimentary set of b flight controls.

The Rooivalk is a large mach with a maximum take-off weigh more than 8000 kg, a rotor diam of 15.08 metres and an overall len of 16.65 metres. Two uprated At built Turboméca Makila turbosh generate 1,877 shp and give a m mum cruising speed of 145 kn Defence cuts and the end of the wa Namibia have led to the tempor abandonment of production pl but a full flight test programme i be conducted with the aim of bring the aircraft and its systems to proc tion status, in case SAAF procu ment plans change, or in case of port orders.

Armscor stresses that bec Rooivalk is entirely South Africa content, it will not be subject to political difficulties which hi many manufacturers, making it pa cularly attractive to pariah nat around the world who are subjec US or UN arms embargoes.

Following-on from the Alpha XH-1 was the Beta XTP-1 systems trials aircraft, an extensively-modified Puma. This featured stub wings for weapons carriage.

Rooivalk finally emerged as a highly capable attack helicopter, with full air-to-air capability in the form of Kukri missiles. The dynamic system is based on that of the Puma.

Boeing Helicopters MH-47E

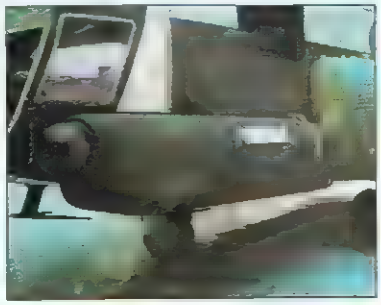
Special Operations Chinook

As part of the US Army's requirement for a fleet of Special Operations helicopters, the service chose the CH-47 Chinook to act as a basis for a heavylift helicopter to fly alongside the MH-60K on clandestine insertion missions behind enemy lines. Consequently Boeing Helicopters was awarded a US$81.8 million contract to develop the MH-47E variant, tailored to the Special Operations mission.

Service input from the 160th SOAG played a large part in fixing the configuration of the Mission Equipment Package (MEP) that turns the standard CH-47D into an MH-47E. Among the many additions are a full glass cockpit with multi-function displays, both pilots having one colour and one mono display. Like the MH-60K, the main aids to nap-of-earth flying at night are radar and FLIR. The FLIR is the same unit, the AN/AAQ-16, which can operate in smoke, fog and total darkness, and can also be used as a sight for Stinger missiles if these become available.

The radar is a Texas Instruments AN/APQ-174 unit, mounted in a large pod fairing on the port side of the nose. It has terrain-following/terrain-avoidance, ground mapping and air-to-ground ranging modes, permitting safe terrain-following flight down to 30m (100ft). These sensors are integrated with the glass cockpit and the other main navigation aid, the moving map display.

Further features of the MH-47E are Textron Lycoming T55-L-714 engines, each developing 3593 kW (4,818 shp), an increase of 22 per cent in take-off power compared with the CH-47D. A full-authority digital electronic controls (FADEC) system provides greater powerplant reliability.



On the MH-47E's port nose is the AN/APQ-174 multi-mode radar set, mounted in a pod. This has a terrain-following mode for safe low-level flight.

Double the CH-47D's fuel capacity is carried, thanks to the large composite fuel tanks developed for the civil 234LR Chinook, standard capacity for the MH-47E being 7828 litres (2,068 US gal). As with the MH-60K, a fixed refuelling probe is fitted, this measuring 8.53m (28ft) in length, and earlier tested on a CH-47D. For ferry flights, an internal auxiliary fuel system can be fitted, allowing self-deployment from the US to Europe.

Internally the MH-47E can accommodate up to 44 troops on insertion missions, or can substitute 11 of these for rapidly unloaded cargo such as wheeled vehicles or artillery. An internal cargo-handling system allows the rapid movement of cargo. A rescue hoist is mounted over the starboard door, to which can be fitted a 'Fastrope' rappelling system for the rapid insertion of troops from the hover.

As with the MH-60K, a comprehensive array of warning receivers and countermeasures are provided. The Aircraft Survivability Equipment (ASE) includes receivers for continuous wave (CW) and pulsed radar, infra-red and laser devices. Jammers, chaff and flares are fitted, and a high degree of emission control is incorporated.

Preceding the definitive MH-47E were at least two 'partial MH-47s'

The MH-47E exhibits the feature now common to most US Speci Forces helicopters, including th long refuelling probe for use wi HC-130 Hercules tankers.

seen during Operation Just Caus Panama. These are CH-47Ds has fitted with an inflight-refuelling pr and some of the sensors associ with the Special Operations miss Production deliveries of the MH- are due to begin in early 1992, air going to the 160th Special Operat Aviation Group at Fort Camp Kentucky, and Hunter Army Field, Georgia, this unit to be jo later by the Oklahoma A National Guard.

Lockheed P-7A

New Generation Patroller

Below: An artist's impression depicts a P-7 launching weapons. Harpoon anti-ship missiles can be carried under the wings, six each side.

First entering service in 1962, the Lockheed P-3 Orion became the West's standard shore-based long-range anti-submarine patroller, and now serves with Australia, Canada, Iran, Japan, the Netherlands, New Zealand, Norway, Portugal and Spain, in addition to the large US Navy fleet. Through steady upgrades (P-3B, P-3C, P-3C Update, Update II, Update III and Update IV), the Orion has kept pace with submarine developments, but in the late 1980s it was becoming increasingly obvious that a successor would be needed to equip US Navy Patrol Wings in the late 1990s and beyond.

The US Navy instituted a competition for a new ASW patroller, answered by Boeing (757 version), Lockheed (Orion airframe upgrade), McDonnell Douglas (MD-90 derivative) and Rockwell. In October 1988, Lockheed's proposal (at the time designated P-3G) was selected for development, the eventual requirement being 125 aircraft with deliveries beginning in 1994 and ending in 2001. A Full Scale Development contract, for US$52 million covering two prototypes, was awarded in January 1989. The first P-7A aircraft is expected to roll out at Palmdale, California, in September 1991, with the first flight following in December.

Left: Although externally bearing a close similarity to the P-3, the P-7 is comprehensively updated internally. A full glass cockpit considerably reduces the crew's workload.

As can be gathered from its earlier designation, the P-7A is closely based on the P-3 Orion, but in fact has little airframe commonality. The advances in manufacturing techniques and materials over the last 30 years have allowed Lockheed to produce a much safer, cheaper and more effective airframe. It is slightly larger than the P-3, having a 1.93m (6ft 4in) longer fuselage, larger tail surfaces and a wing span some 2.13m (7ft) greater.

The most notable improvement comes in the shape of the engines, these being new-technology General Electric T407 turboprops, each in the 5,000-hp class and controlled by FADEC (full authority digital electronic control). Driving five-bladed Hamilton Standard modular composite propellers, the engines give the P-7A much increased payload and range capabilities compared with the Orion, with vastly increased reliability and substantially reduced noise output. The prediction for the P-7's time-on-station at 2960 km (1,600 nautical miles) is 5.9 hours.

Mission avionics in the P-7A be the same as those being develc for the P-3C Update IV, includi Texas Instruments AN/APS-13 radar, AN/ALR-77 tactical electr support measures system and a family of acoustic sensors to cou the ever-quieter submarines. U 150 sonobuoys can be carried ternally, with provisions for anc 150 in pods under the wings. Ar ment will be housed in a 5.08m 8in) long weapons bay in the forv fuselage, and up to 12 pylons u the wings. In addition to the d charges and torpedoes for anti- marine warfare, AGM-84 Harp anti-ship missiles will also be car

Other improvements over Orion include a 94 per cent reduc in vulnerability thanks to fuel tan erting, dry bay fire suppres systems and other enhancements. cockpit environment is consider altered with a two-man full 'g cockpit replacing the three-man logue cockpit of the Orion. A nev conditioning system will provi 'shirt sleeve' environment, benefi crew and avionics alike.

Replacing Orions in US Navy vice, the P-7A will introduce a sig cant upgrade in capability, whil troducing a new era of reliability economy. One export order is alr assured, this being to the West man Marineflieger, which requir to replace its ageing Atlantics MFG 3. The German company l nier has received some participati the programme. Other ex customers seem likely as their Or and other patrol aircraft reach o lescence. Heading the list is the Ur Kingdom, which will need a hi effective ASW patroller to replac RAF's fleet of Nimrods, now sh ing signs of corrosion.

Rockwell/Messerschmitt-Bölkow-Blohm X-31A EFM

The dawn of agile wings

The X-31A, rolled out on 1 March 1990, is a demonstrator for the joint US/German EFM (Enhanced Fighter Manoeuvrability) programme. This is a NATO co-operative project initiated under the Nunn-Quayle R&D Initiative. The US Defense Advanced Research Projects Agency and the Naval Air Systems Command are working hand-in-hand with the Ministry of Defence of the Federal Republic of Germany to develop the X-31A.

Rather than being a technology demonstrator, proving advanced engineering and generating technical data, the purpose of the X-31A is to demonstrate the tactical applications of EFM features. The aircraft is designed to expand the normal flight envelope, allowing manoeuvring and control in the post-stall regime. This gives dramatically increased capability in the close-in, all-aspect combat environment, without compromising beyond-visual-range capability.

Rockwell and MBB believe that controlled flight at very high angles of attack will continue to become more and more important in air-to-air engagements. The ability to out-turn an opponent, or to 'point' the fuselage off axis to fire a missile, will be the most important factor in future air con In their promotional literature R well points out that "Close-in co is here to stay," adding that the U is studying highly manoeuvrable craft and that the MiG-29 and S

Manoeuvring canard foreplanes, a complex delta wing and undernose chin intake are features of most fighter projects currently under way.

The X-31 represents a major investment in future combat aircraft agility, results being closely shared by the US Navy, DARPA and the German MoD.

are already demonstrating departure-free low speed/high alpha capability. This makes enhanced manoeuvrability the key to success in any future combat.

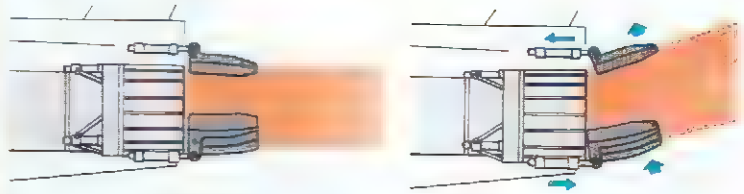
The EFM features being demonstrated by the X-31A are expected to yield a very high payoff in air-to-air combat. Rockwell estimates that post-stall manoeuvre capability will give twice as many first shots and triple the 'exchange ratio' (the ratio of aircraft downed to aircraft lost). Improved agility and enhanced deceleration will have similar effects, while improved negative *g* capability is thought to double the chances of surviving a guns attack. Finally, 'off-axis' fuselage pointing will quadruple the exchange ratio in gun engagements.

The X-31A is based on work begun by MBB in 1977, and is still largely based on that company's proposed configuration for the EFA, the TKF-90, with the same wing. Rockwell joined the project in 1983, bringing with them valuable experience gained with the HiMAT RPRV. From this point, it was decided to use three yaw-producing paddles (as pioneered by the US Navy on the F-14 spin demonstration aircraft) as a means of thrust vectoring, deflecting the thrust through some 10° to 15°.

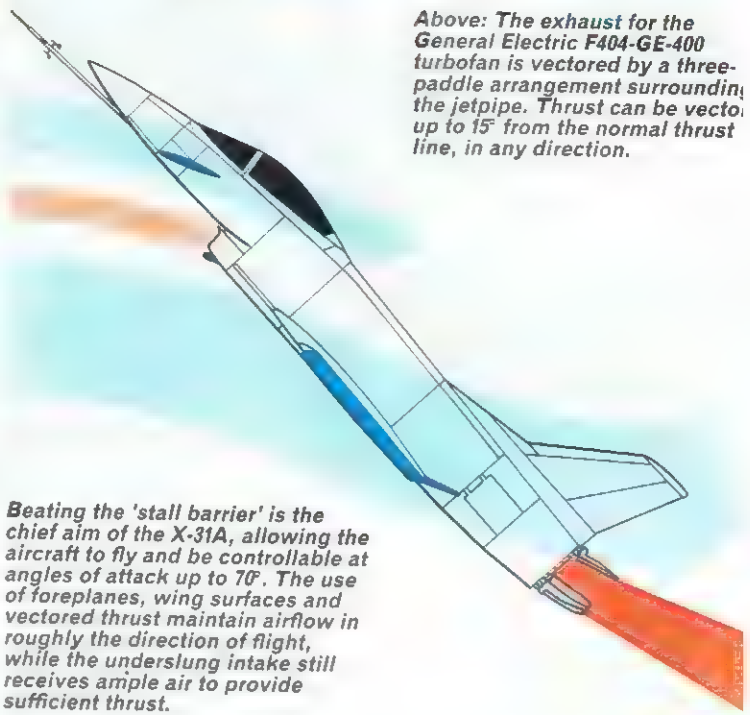
The X-31A's intake has a large lip which deploys downwards at high angles of attack to trap more air. The elevons operate through a large deflection.

The X-31A programme is split into four distinct phases. Phase I covered conceptual design, Phase II the design of the demonstrator and definition of the manufacturing approach. Phase III (funded in August 1988) covers detailed design, manufacture of two prototypes, and a limited flight test programme, while Phase IV is to cover a comprehensive flight test programme, establishing the feasibility of controlled flight in the post-stall region, and including simulated combat between the two prototypes and against dissimilar aircraft types.

The workshare between the two companies is divided in proportion to national funding, with Rockwell taking overall responsibility and the largest share. Rockwell is responsible for drawing up the various requirements, and for ensuring that they are met. The American partner is also responsible for aerodynamics and for agility and conventional performance. Rockwell manufactures the fuselage, fin and canards. MBB, as junior partner, is responsible for the flight control software and for post-stall performance. It manufactures the wings and thrust-vectoring paddles.



Above: The exhaust for the General Electric F404-GE-400 turbofan is vectored by a three-paddle arrangement surrounding the jetpipe. Thrust can be vecto up to 15° from the normal thrust line, in any direction.



Beating the 'stall barrier' is the chief aim of the X-31A, allowing the aircraft to fly and be controllable at angles of attack up to 70°. The use of foreplanes, wing surfaces and vectored thrust maintain airflow in roughly the direction of flight, while the underslung intake still receives ample air to provide sufficient thrust.

The two prototypes are to undergo an initial flight test programme at Palmdale until the end of 1990, when they will be transferred to the NATC at NAS Patuxent River, Maryland. There they are to be flown by Rockwell, MBB, USN, USAF and German armed forces pilots.

Rockwell is looking to achieve four distinct goals. It wants to demonstrate Enhanced Fighter Maneuverabil and investigate its tactical appli tions. It will develop the design quirements and a data base for fut advanced fighters, and develop a validate methods of producing prot types at very low cost. With this mind, the X-31A makes considera use of existing components manuf tured for a variety of production a craft types. The ejection seat, instr ment panel, stick, throttle, cano and engine are all standard F/A- Hornet components, while the lan ing gear comes from the F-16 (alb with Cessna Citation mainwheels a A-7D tyres!). The flight control cor puters are the same as those used the Lockheed HTTB and other pa come from the T-2C, F-20, F-5E a even the V-22.

Ken Dyson, Rockwell's chief te pilot and director of flight test, expec the X-31A to be "a good handling ai craft with 'Spiffy Performance'. Son aircraft fly with a 10° to 15° maximu angle of attack. A fighter will have t to 30°. The X-31, though, will f with a 70° angle of attack, giving it i creased manoeuvrability and maki it more effective in a dogfight close-in air-to-air combat. The a craft continues a long lineage of Ro well and MBB aircraft, and is worthy addition to the long list X-designated research aircraft.

British Aerospace

Hawk 100

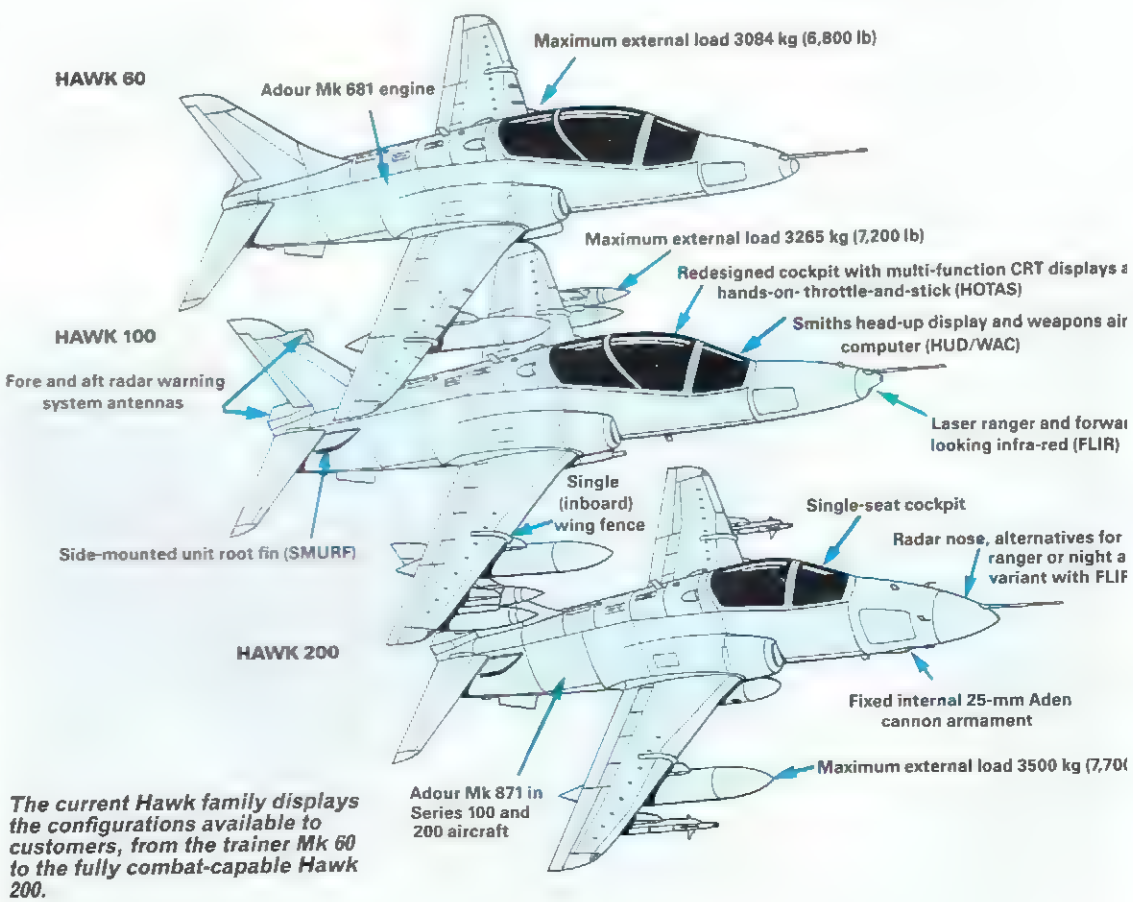
Hawk 100 in close support configuration, displaying the laser rangefinder/FLIR nose. The underbelly cannon pod is the same 30-mm Aden Mk 4 unit, with 120 rounds, as fitted to the RAF's T.Mk 1As.

Although design work for the Hawk two-seat trainer was undertaken in the late 1960s, it was two decades later that BAe began to capitalise on the aircraft's potential as a light combat machine. This has been achieved in two parallel steps: the Hawk 100 attack-capable trainer and the Hawk 200 (described separately), which leaves all instructional duties behind. Although the emergence of the Hawk 100 was not unconnected with a slowing-down of trainer orders, it represents a logical progression from the Srs 60 export model of trainer. With combat aircraft performance now on a plateau, advances in capability are being derived from computerisation, miniaturisation and 'smart' weaponry, making it feasible for a converted trainer to cause more damage to a ground target than a purpose-designed fighter-bomber of a previous generation.

Significantly, the Hawk 100 incorporates the MIL STD 1553B digital databus found in all modern Western combat aircraft. This integrates a Singer Kearfott SKN 2416 inertial navigation unit (as in the F-16 Fighting Falcon); a Smiths Industries advanced HUD/WAC; a modern air data sensor; an optical laser-ranging and FLIR package; a new weapons management system; a radar warning receiver; and provision for fitment of an ECM pod. Cockpit details include a full-colour multi-purpose CRT for each occupant, and HOTAS controls. Considerable effort has clearly been made to give the Hawk as many as possible of the aids available to larger and more costly military aircraft.

In common with the Srs 200, the aircraft has a subtly modified 'combat wing' with fixed leading-edge droop to give better lift and manoeuvrability between Mach 0.3 and 0.7. Side-mounted horizontal root tail fins (SMURFs) are attached to the rear sides of the fuselage, their effect being to restore tailplane authority at high angles of attack. Flaps are modified to allow quarter-setting – known as 'combat' flap' – to be manually applied. Accordingly, the aircraft can sustain more than 5g at 345mph (556km/h) at sea level. Though a Mk 871 version of the Rolls-Royce/Turboméca Adour turbofan develops slightly more power than the Hawk Srs 60's powerplant, the new thrust of 26.0kN (5,845lb) is insufficient to increase the weapon load beyond the 3,084kg (6,800lb) achieved by the earlier Hawk.

An aerodynamic prototype of the Srs 100 flew on 21 October 1987 in the form of company demonstrator G-HAWK/ZA101. BAe is hoping to sell the aircraft to some existing Hawk trainer operators seeking enhanced combat capabilities without the initial outlay and additional operaing costs of a separate aircraft type. Abu Dhabi has ordered 12 to augment its trainer fleet, but 16 for Brunei will be that country's first jet-powered military aircraft. India has a requirement fo to 100 Hawk-type trainers to assembled locally, competition in area coming from the Dass Breguet/Dornier Alpha Jet.



The current Hawk family displays the configurations available to customers, from the trainer Mk 60 to the fully combat-capable Hawk 200.

Left: The Hawk 100 and 200 f together, both equipped wit mounted radar warning rece The 200 is in the air defence configuration, with wing-mo AIM-9L Sidewinders and tan

Above: The prototype Hawk 2 was lost in a crash. It is seen h 'clean', displaying the agility a performance of the type. Cann armament consists of two 25-m Adens.

BAe

Hawk 200

In the Srs 200 Hawk, BAe has produced a single-seat combat aircraft which discards all training capability. Like the Srs 100, it has attractions to existing Hawk operators, being 80 per cent similar in construction and powerplant. Avionics are the same as those of the Srs 100, except that provision is made to change the laser of FLIR nose to a radome for Westinghouse APG-66H advanced, multimode radar. Deletion of one cockpit allows a pair of Aden 25-mm cannon to be installed internally, so freeing hardpoints for additional weaponry. Hawk 200, has the 'combat wing', SMURFs, and slightly taller fin of the Srs 100.

Weapon load is increased to 7,700lb (3,493kg). Stores can be carried on the centreline; on four wing attachments, re-rated to 2,000lb (907kg) each; and newly-added wingtip rails for AIM-9 Sidewinder or similar AAMs. In its radar-equipped version, Hawk 200 can operate with the BAe Sky Flash AAM or in the anti-shipping role with BAe Sea Eagle missiles. With two Sidewinders and two drop-tanks, the aircraft could loiter for three hours at 115 miles (185 km) from base, or achieve a point intercept at 828miles (1,333 km). Ground attack missions with 3,000lb (1,360kg) of ordnance can be mounted over 587 miles (945km) in the hi-lo-hi regime, whilst anti-ship radius with one Sea Eagle and two tanks is 767 miles (1,234km).

Different standards of equipment allow the Hawk 200 to suit a broad range of requirements and pockets. The basic day fighter has an attack sight and AHRS, but relies on radio aids for navigation. If required, it may add an INS, HUD/WAC, HOTAS controls, laser range-finder, IFF and RWR, plus a Tracor AN/ALE-40 (or similar) chaff/flare dispenser at the base of the fin. A Hawk 200 for night missions has a modified nosecone with optical flats for a FLIR and laser-ranger, whilst the all-weather option includes APG-66 radar.

Announced in 1984, the Hawk 200 prototype, ZG200, first flew on 19 May 1986, but was lost due to pilot incapacitation soon afterwards. A second aircraft, ZH200, replaced it on 24 April 1987. An arms order, provisionally agreed by Saudi Arabia in July 1988, includes 60 Hawks, of which many will be Srs 200s, but a prospective sale to Iraq of both Srs 100 and 200 aircraft was embargoed by the UK government.

English Electric Lightning

Lightning Lingers On

Although No. 11 Squadron lost its declaration to NATO at the end of April 1988 and flew its last sortie on 30th June 1988 (delivering the last of six aircraft to Cranfield for Arnold Glass), the Lightning is still alive and well and fulfilling a vital role at BAe Warton.

Five aircraft remain airworthy at their Warton birthplace, and are specially instrumented for use as radar targets in the ongoing Tornado ADV development programme. This involves the fitting of (classified) 'special equipment', presumably a Lundberg [illegible] the natural-aluminium finished XP693, a long-term Warton resident previously used as a testbed for the 27-mm cannon. This aircraft had only flown 1,028 hours by March 1990, and may have many years' service left.

The other four aircraft are ex-Binbrook Wing, and have clocked up more flying hours. The latter aircraft will be retired as they reach the end of their fatigue lives, beginning with XR724 (4,103 hours by March 1990) at the end of 1990, and probably ending with XR773 (3,416 hours) in late 1991.

velopment work and for continuation training for Britain's last Lightning pilots.

BAe Warton's Lightnings all sport overwing tanks for extended endurance. They fly subsonically as radar targets in support of the Tornado ADV programme.

Engineering and spares suppo these veterans should present problems, since BAe Warton many skilled staff with enormou perience on the aircraft, and most of the 22 aircraft flown from Saudi Arabia in January 198 main in open storage on the airfi

Lockheed F-117A 'Stealth' Fighter

THE BLACK JET

The F-117A is perhaps the most unusual-looking aircraft ever flown, but its strange shape serves a vital purpose. This large, subsonic fighter bomber is designed to be virtually invisible to radar. After years of denials, the Pentagon has finally taken off some of the wraps, and Bill Sweetman assesses this, the world's first stealthy aircraft.

Lockheed's Advanced Development Projects (ADP) division, informally known as the Skunk Works, may be the only aerospace design team whose achievements can truthfully be called incredible. Nobody believed that the U-2 could touch 80,000 feet, nor that the SR-71 could top 95,000 feet and routinely fly 15,000-mile missions. Most experts were equally scornful of reports, appearing in 1976, that the Skunk Works was designing a fighter which would be practically invisible to radar.

The impetus for the Lockheed F-117A project seems to have been operational experience in the Vietnam bombing campaigns (in 1965-7 and 1972) and in the Middle East war of October 1973. In all three campaigns, radar-guided surface-to-air missiles (SAMs) represented a threat to strike aircraft which could not be negated by tactics nor countermeasures.

Low-observables (LO) or stealth technology was identified as one potential solution to the problem. If the radar cross-section (RCS) of an aircraft could be drastically reduced, the performance of all the radar-guided systems ranged against it would be degraded, in a reliable and predictable manner.

Stealth technology had been developed in many experimental programmes – most of them classified – since the 1940s. Shaping techniques and radar-absorbent materials had been used successfully on a number of aircraft, notably the Lockheed A-12/SR-71 family and the Teledyne Ryan AQM-91A drone. However, the development of a tactical Stealth aircraft, which would have to operate at lower altitudes in closer proximity to SAM systems, would require a larger RCS reduction.

Around 1975, Lockheed ADP engineers devised an RCS-reduction technique which came to be known as 'faceting'. Harnessing the increasing power of computers to the problems of air design, faceting made it possible to reduce by three to four orders of magnitude – a fact between 100 and 1,000 – compared with a ventional aircraft, translating into a three- to fold reduction in radar detection range.

While other companies were studying Stea notably Northrop, Boeing and General Dyn ics – faceting offered the best chance to prod workable Stealth aircraft quickly. In early Lockheed received a contract from the De Advanced Research Projects Agency (DARP build and test two sub-scale prototypes Stealth strike fighter. The programme was c named 'Have Blue'. A few months later, H ever, Have Blue was transferred to US Air F control, and became a 'black' or Special A project.

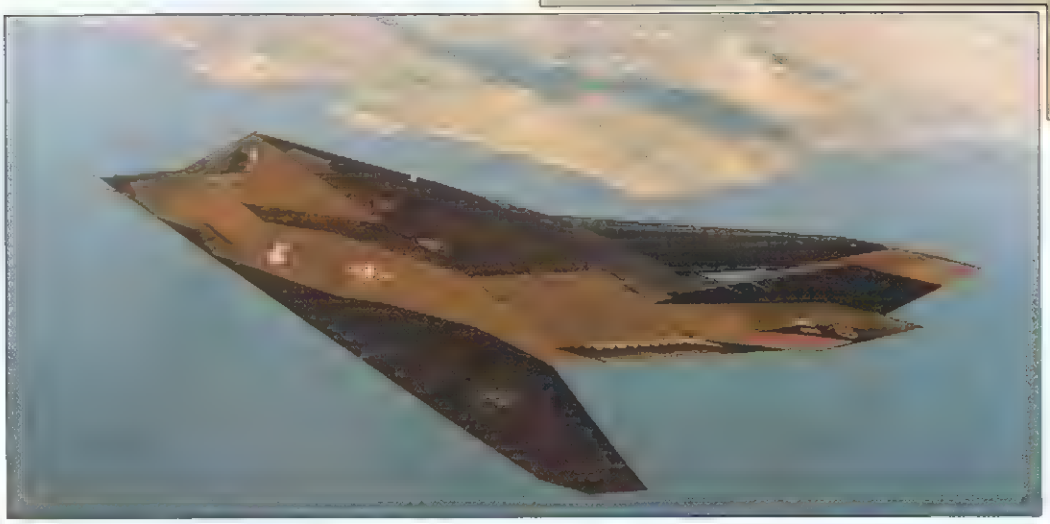
First flight

The Have Blue prototypes were complet Burbank, California, with impressive sp Lockheed test pilot Bill Park made the first f in January or February 1978, from the US Force's secret flight-test centre at Groom L Nevada. The second aircraft joined the test

They say that if an aeroplane looks right, it'll right. The F-117A is apparently the exception which proves the rule, possessing admirable handling characteristics. After nearly 12 years a black programme, whose very existence w denied until November 1988, the aircraft was publicly unveiled in April 1990.

The badge of the 4450th Tactical Group, Nellis AFB.

Above: The F-117A is a large aircraft, almost t size of an F-15 Eagle, as can be seen in this photograph of a refuelling contact with a gia KC-10 Extender. The aircraft's unusual paint, apparently the same as that used on the TR-1 and SR-71, looks very different under differer lighting conditions and, when well worn, var between a dark bluish grey to the true matt black.



Left: The F-117A's long, narrow exhausts mix jet efflux into a very broad swathe, and can o be seen from above. It is not known whether F-117A can inject CFCs into the efflux to mak contrails invisible, as can the B-2.

gramme in March or April, Park being assiste USAF Lt Col Ken Dyson.

The Have Blue design resembled the F-117, apart from a less dramatically notched t ing edge and rudders which were mounted a wing-body junction and canted inwards. It about 60 per cent as large as the later aircraft, had a gross weight around 12,000 lb. It powered by two non-afterburning General E tric J85 turbojets. The fly-by-wire (FBW) fl control system was the same Lear Siegler used on the F-16 (the company is now C Astronics) and the landing gear was from an

The first aircraft was lost on 4 May 1978 wh handling problem inherent in the design caus heavy landing and jammed the right main ge that neither a wheels-down nor wheels-up l ing was possible. Bill Park ejected, but was jured and did not fly again.

Dyson continued the flight-test program proving in 100 flights that the Have Blue t nology worked against a wide range of grou based and airborne threat radars and that faceted shape was aerodynamically sound. C test flight in early 1980, however, fire broke and Dyson was forced to abandon the aircra

By that time, development of an operati Stealth aircraft had started, under the coden Senior Trend. Lockheed's experience on H Blue gave it the edge over the competition, a received a contract in November 1978 to dev Senior Trend and build about 20 production craft.

Lockheed F-117A 'Stealth' Fighter

Senior Trend was a special-operations asset, designed to attack small, highly protected targets which were, in Pentagon jargon, 'highly leveraged': that is to say, their destruction would hinder enemy operations, or aid friendly forces, out of proportion to their intrinsic value. Examples could include specific bridges, tunnels and rail or road junctions, essential to the movement of land forces; command, control and communications centres; and main air defence sites. As well as being stealthy, the new type would need to have a considerable range – operations in the Middle East theatre were, at this time, considered as likely as combat in Europe – and the ability to find its targets autonomously at night; no effort would be made to make the aircraft invisible in daytime.

The programme advanced rapidly, aided by its black status and energetic management by Lockheed and the USAF. The first of five full-scale development (FSD) aircraft made its first flight from Groom Lake on 18 June 1981 in the hands of Lockheed's Hal Farley. (The aircraft was now designated F-117A, but the Senior Trend codename was retained for the entire developmental, production and operational programme.)

The F-117A required no significant exterior changes as a result of flight tests; developing a satisfactory de-icing system for the inlets proved to be one of the most serious problems. One F-117A was lost on its first flight in June 1982, because the inputs from the roll and yaw gyros into the FBW system had been transposed. It crashed immediately on lift-off, and Lockheed pilot Bob Ridenauer was seriously injured.

New base

Senior Trend was still highly secret, but the USAF did not want to keep the operation at Groom Lake, which housed many different classified projects. Instead, a brand-new base was built on the Tonopah Test Range (TTR), abutting the north-west corner of the Nellis AFB ranges. The F-117A unit, formed in 1980 as the 4450th Tactical Group, would also operate A-7s, with Nellis tail codes, as a cover for their actual task. In October 1983, just under five years after the programme started, the 4450th TG was declared operational at TTR, with about a dozen F-117As and 18 A-7Ds.

The aircraft that equipped the 4450th TG was and will remain unique. The F-117 is about the same size as an F-15. It is of modified delta planform, with small wings mated to a broad lifting body. The shape is defined by the need to reduce and control the scattering of radar energy from the aircraft. The principle behind faceting is the elimination of curved surfaces, which tend to scatter radar energy evenly over a wide arc, in favour of flat panels meeting at sharp edges. The flat facets will not reflect a radar beam back towards the radar unless the beam makes two perfect right-angles to the surface, and they all slope so far away from the vertical that this is unlikely to happen. Even the wing and rudder surfaces are faceted, not cambered.

Some edges of measurable radius are unavoidable – on the wing leading edges and around landing-gear doors, for example. Their effect is minimised in three ways. First, edges are angled away from the most important illumination angle – directly in front of the aircraft. This is why the F-117A is the only subsonic aircraft with a 67.5-degree sweep angle. Second, inside corners are avoided, because they create RCS 'hot spots'; the F-117A has two, and they are visible only from behind the aircraft.

Thirdly, all the edges are grouped on a small number of alignments. In plan view, the leading edges of the wings are parallel to the leading edges of the rudders, on each side. Each cut-off wingtip is parallel to the afterbody on the same side, and to the wing trailing edge on the other side. In all, there are six primary alignments: one directly to each side, one aligned with each wing leading edge and one corresponding to each wing trailing edge.

The edges of every aperture or break point in the aircraft conform to these primary alignments. If the edge cannot be made continuous along the alignment, it is formed into a zig-zag pattern that conforms to two of them.

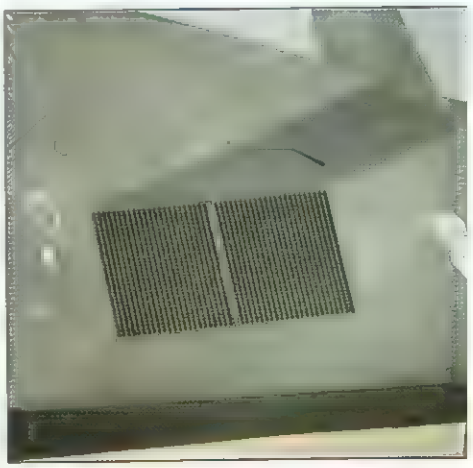
A radar beam illuminating such a shape is scattered as a number of relatively strong lobes – one per facet, one per edge alignment – but the lobes are usually directed away from the radar. Even if one main lobe points towards the radar, this is a transient condition, because of the movement of the aircraft. The echo would disappear on the next scan, and would be indistinguishable from noise.

Aerodynamically, the F-117A seems to work quite well. It is described by its pilots as a pleasant, smooth aircraft to fly. Its characteristics are not unlike those of deltas, like the F-106. Landing and take-off speeds are quite high (a parachute is always used on landing) and the aircraft flies nose-high at low speeds and decelerates rapidly in a sharp turn. The thrust/weight ratio at maximum take-off weight is 0.4:1, which is not generous, particularly out of TTR on a hot day. The absence of curves and camber does not appear to manifest itself in any unique flying behaviour, probably because the break angles between the facets, measured streamwise, are not very large.

The controls are conventional: there are two elevon sections on each wing and two all-moving rudders, which have no pitch-control function. (One F-117A made it safely back to base after losing a rudder during a high-speed test.) The F-117A is not naturally stable: it has a quad-redundant FBW flight control system, similar to that of the F-16, with no mechanical backup. According to

Above: The change of designation from the 4450th Tactical Group to the 37th TFW in October 1989 when the project was de-classified made little difference to the unit badge, which remained virtually unchanged.

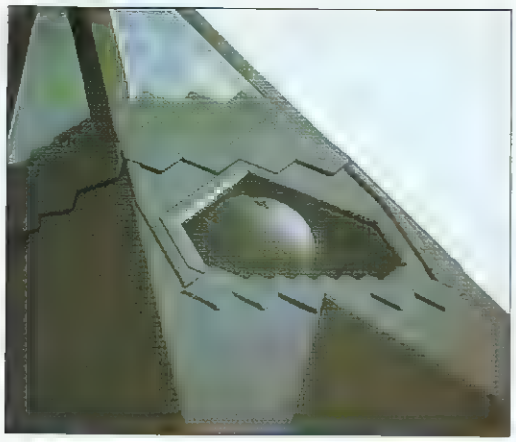
Above: The F-117A pilot sits on a standard AC II zero-zero ejection seat. The heavily framed canopy must be jettisoned before this can be used: through-the-canopy ejection is not possible.



Above: The intakes are covered by a fine me The gaps between the strands are smaller th most radar wavelengths, allowing the intake reflect radar as though they were solid.

Below: A view of the nose shows the angled data probes and the faired-in DLIR turret bel the starboard side of the nose.

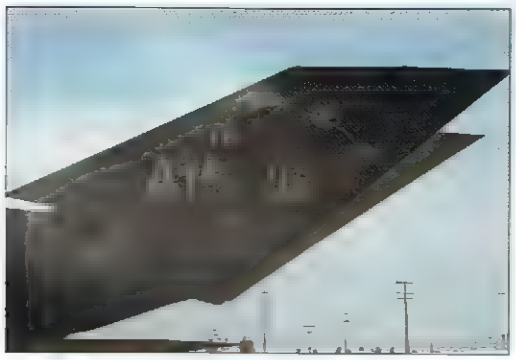
Right: The F-117A's skeleton is covered by flat panels, or facets, which scatter what little radar energy is not absorbed by the RAM covering in all directions so that very little of it is bounced back towards the radar receiver.



Above: The FLIR turret in the nose of the F-117A performs both imaging and weapon-aiming functions. When laser-guided bombs are used the lower DLIR (downward-looking infra-red) turret follows the target as it disappears from the FLIR's field of view, and designates it for a few seconds before the bombs impact.

Below: The landing gear is a retractable tricycle undercarriage. The nosewheel retracts forwards, while the mainwheels swivel through 90° before retracting forward.

Below: In peacetime, and for training missions, the F-117As carry comprehensive (though toned-down) markings. On the fins the aircraft carry the last three digits of their serial number, the Tactical Air Command badge and a 'TR' tailcode, indicating their Tonopah Test Range base. This F-117A, probably one of the squadron commander's aircraft, also carries the squadron designation of the 'Nightstalkers', the 415th TFS.



engineers, it would have been extremely difficult, if not impossible, to design a practical stealth aircraft with three-axis natural stability. The only aspect of the F-117A flight control system that is fundamentally different from a non-stealthy aircraft is the means of sensing air data. In place of conventional pitch and yaw vanes, the F-117A has four nose probes, each with four-sided pyramidical heads with a tiny hole in each face. Differential readings from each hole give pitch and yaw information.

The F-117A is largely made of aluminium, with some titanium around the engines and exhaust system. It has a complex skeletal structure, to which the main facets are fastened separately; this was the only way to achieve the required accuracy at the edges.

Most of the skin is covered by radar-absorbent material (RAM), which reduces the main-lobe reflections from the facets and virtually eliminates any scattering outside the main radar beam. The RAM is believed to consist of magnetic iron and ferrite particles in a polymer binder; it can also be applied as a putty-like material (to cover fastener heads) and as a tape. Originally, most of the RAM took the form of flexible sheets, bonded to th skin; after the aircraft entered service the USA commissioned a new facility in which the aircra is held in a rotating fixture while RAM is applie by computer-controlled nozzles.

Wing loads

The internal structure is based on a number c complex transverse frames which carry the win loads around the weapon bay openings and th engine access doors; below, longitudinal keels ru between the openings. Twin weapon bays in th centre of the structure can each accommodate 2,000-lb bomb with laser-guidance kit, or almo any smaller weapon. Much of the fuel is house above the weapon bays.

The F-117A is powered by two General Electri F404-F1D2 engines, non-afterburning versions c the F/A-18's powerplant. When design wor started, there was neither the time nor the mone to develop a new engine, and two modern fighte engines were available – the Pratt & Whitney F10 and the F404 – and two F404s were found to pro vide the right amount of thrust for the missior The engine's near-turbojet cycle (with a bypas

ratio of 0.34:1) produced more thrust for a given mass flow and reduced the size of the inlet and exhaust system. With its augmentor removed, the F404 also has an excellent thrust/weight ratio of 6:1, better than the afterburning engines of the previous generation.

The inlet and exhaust systems are designed to mask the signatures of the engine, which presents, in the front, a whirling mass of reflective metal and, in the rear, a similar mass, together with the infra-red signature of hot metal and 140 lb of hot air per second.

The straight inlet ducts are masked by grids of knife-edged blades, each faceted in section and covered with RAM. The spaces in the grids are smaller than the wavelengths of most radars, so they reflect most energy in the same way as a solid surface. Radar energy that does penetrate the grid is absorbed by RAM in the duct. At low speeds, the inlets are augmented by suck-in doors above the ducts. The grids are electrically heated, but even a small amount of ice can rapidly cause problems. A light on each side of the F-117A's cockpit can illuminate the inlets if the pilot needs to check them for ice.

The exhaust system changes from a circular section at the rear of the engine to a narrow slot at the trailing edge of the tail. The lower lip of the slot is longer than the upper edge, and bends upwards, masking the exhaust completely from any point below the aircraft. The exhaust plume – the most visible part of any aircraft in the IR spectrum – is wide and flat, and this makes it cool down more rapidly after it leaves the aircraft.

Inside the exhaust slot, a row of vertical baffles helps to mask the interior from radar detection and provides structural strength – without them, the exhaust would tend to bulge under pressure. The exhaust system is complex, incorporating sliding elements and quartz tiles to resist heat without changing its shape.

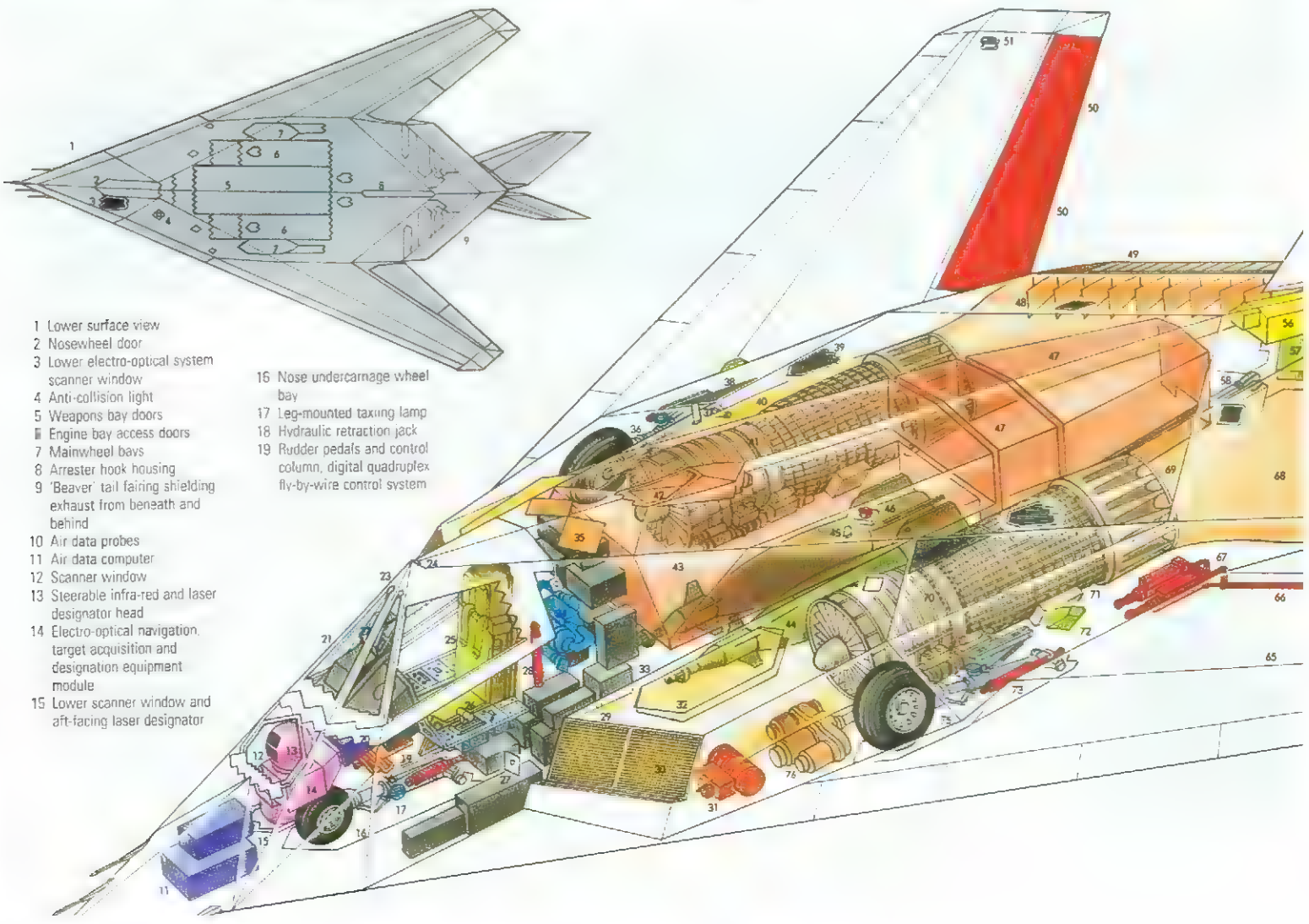
The F-117A's complex canopy provides merely adequate visibility for normal flight, take-off and landing, but the pilot can see very little above or behind him. The flat panes are treated to reduce radar reflectivity, and the entire canopy opens for cockpit access; it is a heavy unit and is provided with powerful explosive rams to remove it for ejection. On top of the canopy is a small, low-intensity light that illuminates the rotating in-flight-refuelling receptacle.

The cockpit is narrow at the top but wide at seat

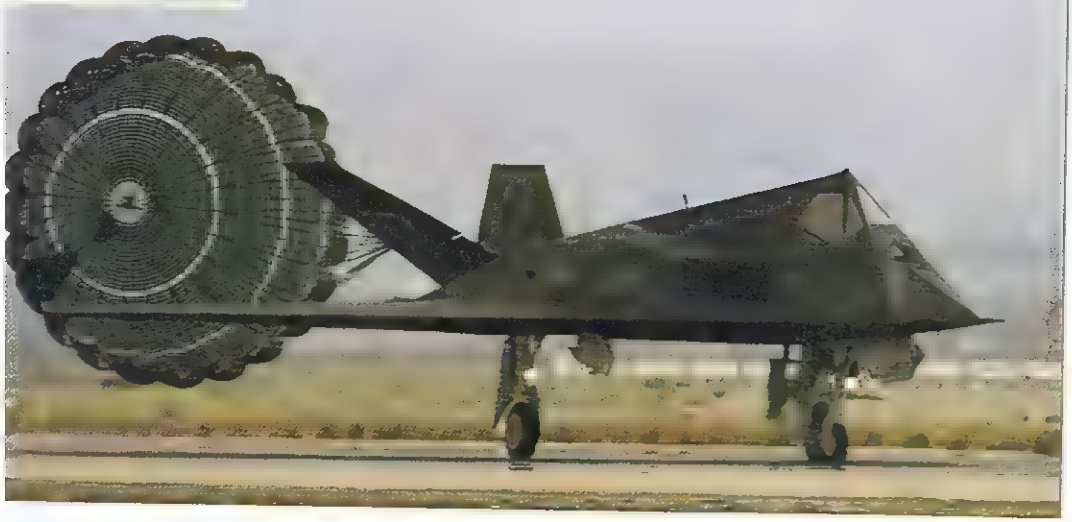
Inset: Two F-117As sit together on the ramp Nellis AFB during the official public unveil the aircraft. This event drew a huge crowd Above: One of the aircraft lands at Nellis, retarded by a sinister black drag chute.

Lockheed F-117A

The F-117A is a fascinating-looking aircraft, but it is even more interesting beneath the skin. Lockheed's designers have had to solve thousands of complex problems in order to fit large amounts of equipment and systems into the aircraft, without compromising the carefully designed exterior shape.

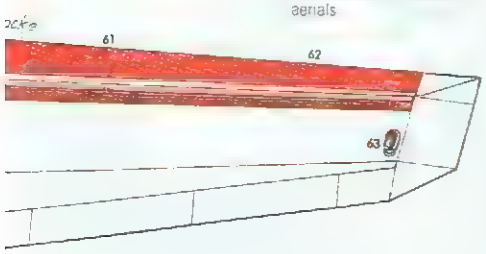


1 Lower surface view
2 Nosewheel door
3 Lower electro-optical system scanner window
4 Anti-collision light
5 Weapons bay doors
6 Engine bay access doors
7 Mainwheel bays
8 Arrester hook housing
9 'Beaver' tail fairing shielding exhaust from beneath and behind
10 Air data probes
11 Air data computer
12 Scanner window
13 Steerable infra-red and laser designator head
14 Electro-optical navigation, target acquisition and designation equipment module
15 Lower scanner window and aft-facing laser designator
16 Nose undercarriage wheel bay
17 Leg-mounted taxiing lamp
18 Hydraulic retraction jack
19 Rudder pedals and control column, digital quadruplex fly-by-wire control system



The large size of the F-117A can be gauged from the diminutive appearance of the pilot sitting in the cockpit.

20 CRT head-down displays
21 Non-radar-reflecting treated cockpit transparencies
22 Head-up display (modified F-18 unit)
23 One-piece, upward-hinging canopy cover
24 Refuelling floodlight
25 ACES ejection seat
26 Engine throttle levers
27 Canopy emergency release
28 Canopy actuator and jettison strut
29 Port engine air intake
30 Intake radar reflective grid
31 Hydraulic equipment bay
32 Intake suction relief door
33 Avionics equipment bay
34 Air conditioning plant
35 Retractable ILS glideslope aerials



36 Starboard main undercarriage wheel bay
37 Retractable communications aerial
38 Flush aerial panel
39 Engine bay venting air grille
Intake bypass air duct
41 Starboard engine bay
42 Rotary inflight-refuelling receptacle
43 Main fuselage fuel tank
44 Ventral weapons bay, two 2,000-lb laser guided bombs shown
45 Communications aerial
46 Detachable anti-collision light
47 Rear fuselage fuel tanks
48 Exhaust baffles
49 Starboard engine exhaust
50 Starboard outboard and inboard elevons
51 Retractable navigation light
52 Tailplane composite leading and trailing edge panels
53 All-moving V-tail rudder surfaces
54 Tailplane pivot mounting
55 Hydraulic actuator
56 Brake parachute housing
57 Ventral radome
58 Emergency arrester hook stowage
59 Port engine exhaust
60 Heat absorbing tiles
61 Port inboard elevon
62 Outboard elevon
63 Port retractable navigation light
64 Wing panel composite edge members
65 Light alloy structure with radar-absorbent material covering (RAM)
66 Elevon torque shafts
67 Elevon hydraulic actuators
68 Engine exhaust duct, spread and flattened
69 Exhaust mixer duct, intake bypass air mixed with engine flow to cool exhaust plume
70 General Electric F404-GE-100D non-afterburning engine
71 Fully automatic digital engine control (FADEC)
72 Radar augmentor fused for normal peacetime operations)
73 Hydraulic retraction jack
74 Undercarriage leg-mounted landing lamp
75 Port main undercarriage wheel bay
76 Airframe-mounted accessory equipment gearbox

level. The pilot has a conventional head-up display (HUD) for basic flight information and infrared imagery, with an up-front control panel beneath it for radio and display mode selection. On the main panel, standard 5-in multifunction displays (MFDs) are installed on each side of a large monochrome CRT screen. The F-117A has a conventional central control column.

Most of the F-117A's unique navigation and attack system is located in front of the cockpit. In 1978, low probability of intercept (LPI) radar was not ready for production. Instead, the aircraft was fitted with a very comprehensive electro-optical suite to find its targets without betraying its own presence.

In front of the windscreen, behind a very fine mesh cover (like the inlet grids, this appears as a solid surface to radar) is a steerable turret containing a dual-field-of-view forward-looking infra-red (FLIR) sensor. Beneath the body, to the right of the nosewheel bay, are a downward-looking IR (DLIR) sensor and a boresighted laser, also in a stabilised turret behind a mesh. The sensors are backed up by a highly accurate inertial navigation system (INS) that uses electrostatically suspended gyros, like the INS fitted to the B-52 and the MX missile.

Finding the target

The system works as follows. The INS guides the aircraft to the target and points the FLIR – set to wide-field – towards it. (When the FLIR is not being used for targeting, it can be locked forward and its imagery displayed on the HUD.) On his large CRT, the pilot searches for the target, having studied the area and any topographical 'cues' before the mission. When he believes he has found the target, he selects the narrow-field FLIR, confirms identification, selects his aim-point and locks on; the FLIR has a contrast-based auto-tracker. If he is using a laser-guided bomb, he releases the weapon at a point when it will fall into a 'basket' – a circular area a few hundred feet above the target, within which its guidance mechanism can hit its objective. As the target disappears under the F-117A's nose, and from the FLIR's field of view, the DLIR acquires it and continues to track it; the DLIR 'lases' the target a few seconds before impact, allowing the weapon to correct its path.

The F-117A's primary weapon is the laser-guided bomb, but the USAF has also said that it can carry "the full range of tactical munitions." This is a remarkable statement, since the USAF defines a 'munition' as almost anything that can hang off an aircraft, including air-to-air and anti-radar missiles; it is not known at present whether it is literally correct. However, the F-117's weapon bays are big enough to hold any weapon in the USAF tactical inventory, although some missiles (such as the AGM-65 Maverick or AGM-88 HARM) would require an extending launch rail. The USAF statement also implies unambiguously that the F-117A is nuclear-capable. Some special weapons are also believed to have been developed for the F-117A.

All operational F-117As are of the type described above, as far as is known; no variations among individuals have been observed. Deliveries of production aircraft started in mid-1982, and must have peaked at about eight or nine aircraft per year in 1983. Although the service planned to buy only 20 aircraft, Congress – in the form of the

House and Senate Armed Services Committees, which had been cleared into the programme – ordered production of extra aircraft from 1985 onwards, until a total of 59 had been authorised: the last was due for delivery in the summer of 1990.

The first operational pilots were selected in 1980. All had more than 1,000 hours of flying time, mostly in jet aircraft; it was later said that the USAF was seeking maturity, not just experience. All were graded as above-average pilots and most had some air-to-ground experience in F-4s, F-111s or A-10s. Those who were selected were returned to their units until the aircraft were ready.

The first operational cadre joined the 4450th TG in mid-1982. (The first pilots joined for four years; it is now a three-year posting.) One of their first tasks was to develop the training programme for the pilots who followed them, establishing the operational pattern until late 1988.

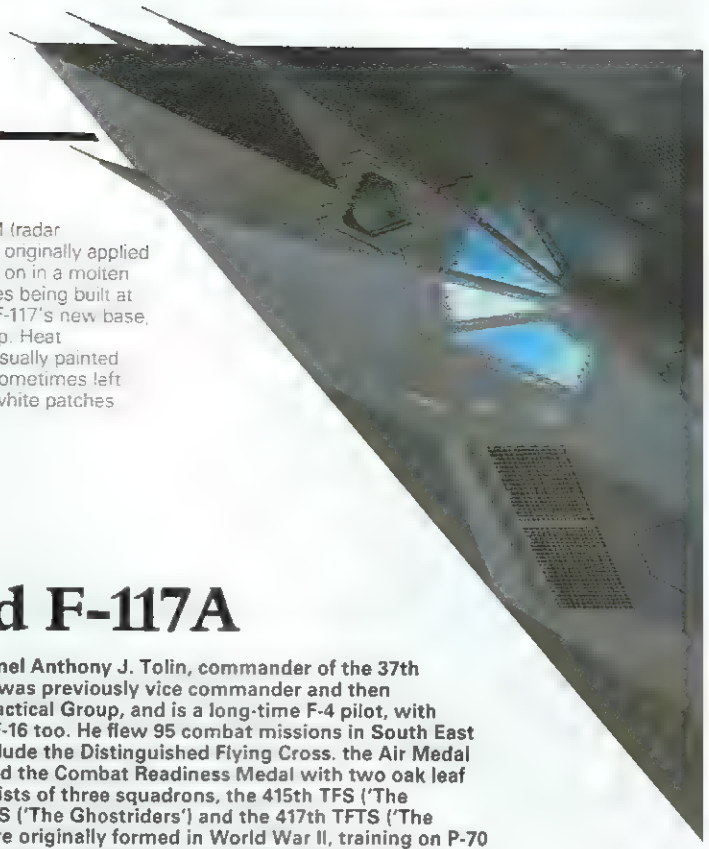
It was difficult, for a number of reasons. There was (and still is) no two-seat F-117. All operational missions would be at night. Because of the secrecy surrounding the project, daytime flying was almost completely forbidden. The aircraft was complex and – in its reliance on electro-optical systems – unique, and its mission required extreme accuracy. Finally, because the force was dedicated to special operations, the call to action could come at any time.

As the aircraft matured and restrictions were lifted – allowing the F-117A to operate in icing conditions, and away from the Nellis range – training became realistic and intense. The new pilot was given some instruction on the simulator before making his first flights in the immediate vicinity of TTR, with an experienced F-117A pilot flying chase in one of the unit's A-7s. He would then go into tactical training, and, having been declared proficient, he would be assigned to one of two operational squadrons: the Grim Reapers or the Nightstalkers.

The operational pilots commuted weekly from Nellis AFB to TTR, arriving on Monday and leaving on Friday. Monday was always a 'light' night, but the other three flying nights were busier, each available aircraft flying two sorties per night. In summer, security dictated that the hangar doors could not be opened before 2100 local time, so that the last aircraft from the second sortie or 'late go' would not land until 0300 or later.

The sorties themselves were demanding, lasting around 90 minutes and extending over much of the Western USA. Operating singly and in complete radio silence, the pilots were tasked with finding and identifying many small, obscure targets and making simulated attacks. Their performance was gauged by videotaped FLIR imagery.

One sortie in three would include an inflight-refuelling from a KC-135 or KC-10. All refuellings were conducted in radio silence with a minimum of illumination – the tanker's anti-collision beacon, one small light under the tanker, and the F-117A's own refuelling-point light. The FLIR helped the pilot acquire the tanker, particularly on clear nights.

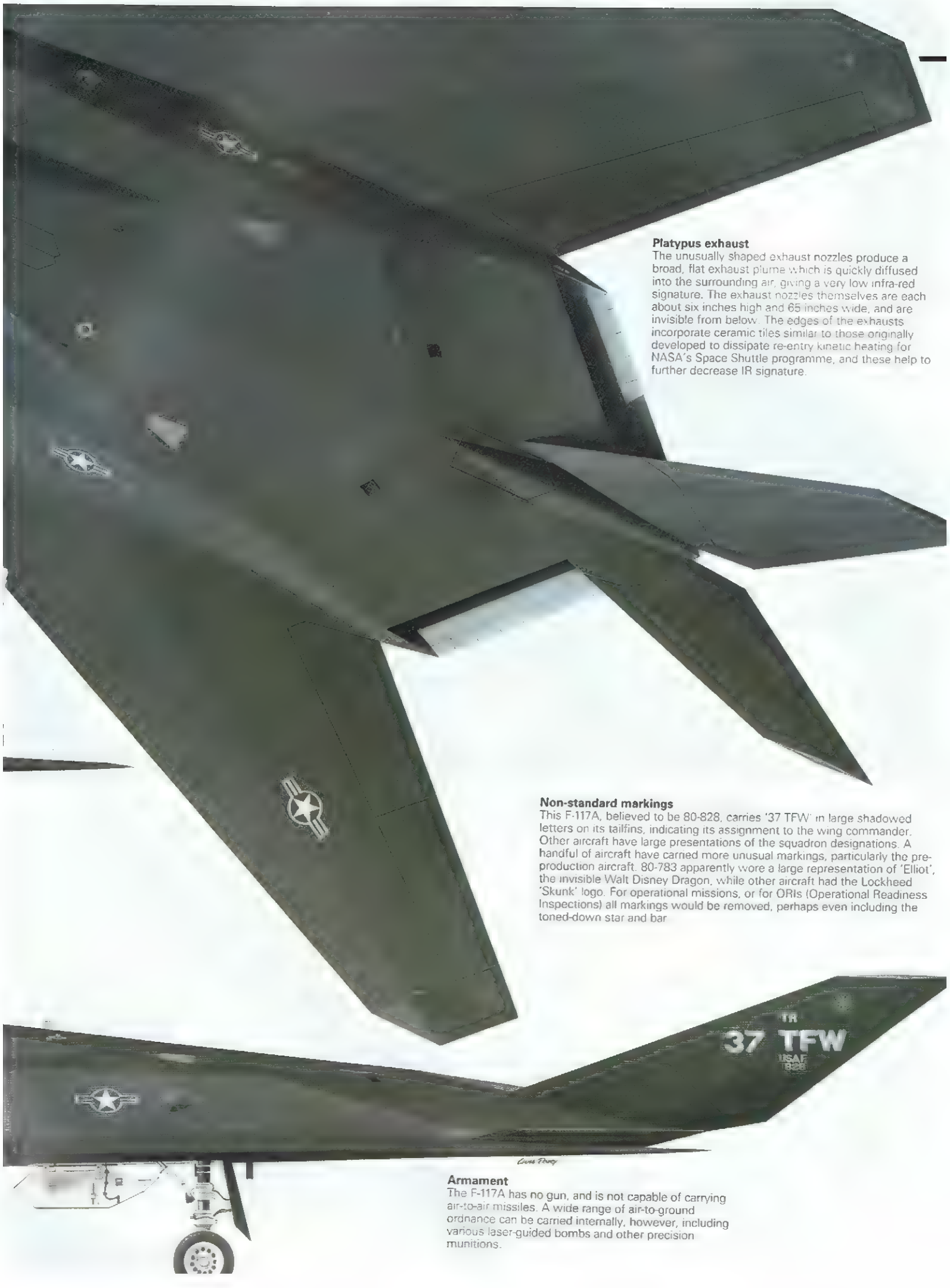


Finish
The F-117A is covered in RAM (radar absorbent material). This was originally applied in sheets, but is now sprayed on in a molten state. Among the new facilities being built at Holloman, earmarked as the F-117's new base, will be a RAM respraying shop. Heat dissipating ceramic tiles are usually painted black, but replacements are sometimes left white. This accounts for the white patches seen on some F-117As.

Lockheed F-117A

This F-117A is flown by Colonel Anthony J. Tolin, commander of the 37th Tactical Fighter Wing. Tolin was previously vice commander and then commander of the 4450th Tactical Group, and is a long-time F-4 pilot, with experience on the F-15 and F-16 too. He flew 95 combat missions in South East Asia and his decorations include the Distinguished Flying Cross, the Air Medal with six oak leaf clusters, and the Combat Readiness Medal with two oak leaf clusters. The 37th TFW consists of three squadrons, the 415th TFS ('The Nightstalkers'), the 416th TFS ('The Ghostriders') and the 417th TFTS ('The Bandits'). All three units were originally formed in World War II, training on P-70 Havocs and going into action with Beaufighters. The 4450th TG had only two unnumbered squadrons, and these were named the 'Grim Reapers' and the 'Nightstalkers'.

Radar reflector
For non-operational flying, large radar reflectors are attached to the F-117A, to make it more visible to civilian air traffic control radar. The high-intensity strobe lights used in peacetime are also believed to be removeable.



Platypus exhaust
The unusually shaped exhaust nozzles produce a broad, flat exhaust plume which is quickly diffused into the surrounding air, giving a very low infra-red signature. The exhaust nozzles themselves are each about six inches high and 65 inches wide, and are invisible from below. The edges of the exhausts incorporate ceramic tiles similar to those originally developed to dissipate re-entry kinetic heating for NASA's Space Shuttle programme, and these help to further decrease IR signature.

Non-standard markings
This F-117A, believed to be 80-828, carries '37 TFW' in large shadowed letters on its tailfins, indicating its assignment to the wing commander. Other aircraft have large presentations of the squadron designations. A handful of aircraft have carried more unusual markings, particularly the pre-production aircraft. 80-783 apparently wore a large representation of 'Elliot', the invisible Walt Disney Dragon, while other aircraft had the Lockheed 'Skunk' logo. For operational missions, or for ORIs (Operational Readiness Inspections) all markings would be removed, perhaps even including the toned-down star and bar.

Armament
The F-117A has no gun, and is not capable of carrying air-to-air missiles. A wide range of air-to-ground ordnance can be carried internally, however, including various laser-guided bombs and other precision munitions.

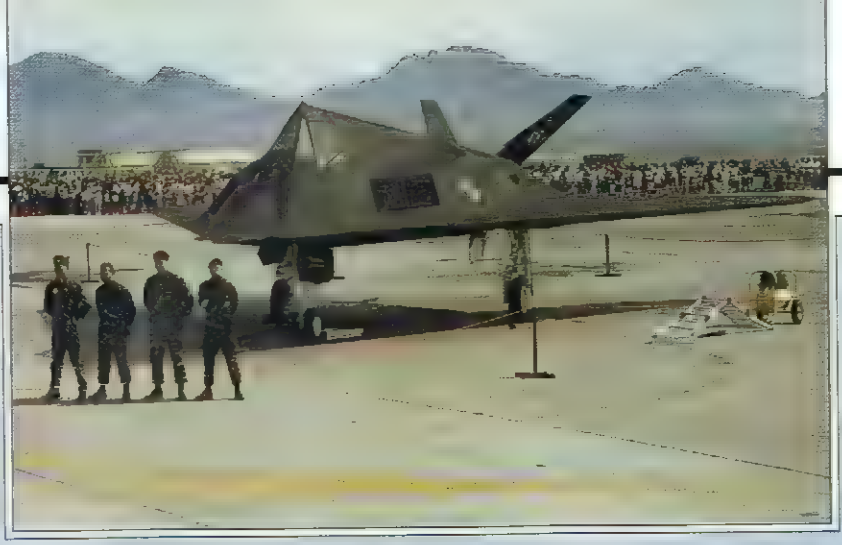
The summer routine required a weekly nine-hour shift in the pilots' body clocks. Even with blacked-out sleeping quarters, the adjustment was never total. Fatigue was almost certainly a factor in the first operational F-117A crash, at 0145 on 11 July 1986. Major Ross E. Mulhare, flying the 'late go' on the last flying night of the week, was killed when his aircraft crashed into a hillside near Bakersfield, California; the aircraft was in a steep dive under power and Mulhare made no attempt to eject. The second operational F-117A crash (and, by May 1990, the last) occurred on 14 October 1987, killing Major Michael C. Stewart. Again, the pilot made no attempt to eject and there was no indication of any mechanical problem. Once again, the investigation focused on disorientation and fatigue.

Pressure on the pilots and a greater training load – due to the delivery of more aircraft and the change from a four-year to a three-year posting – were probably the main reasons behind the Pentagon's decision, in early 1988, to declassify the programme. Delayed by political wrangling, the Pentagon's admission that the F-117 did, indeed, exist came on 10 November 1988. Daytime training operations were immediately stepped up, and combat-ready pilots now fly only two-thirds of their missions at night.

Organisational changes followed declassification. The A-7Ds were no longer required as a cover for the F-117As, and were replaced in their chase-plane and fighter familiarisation role by T-38s. In October 1989, the 4450th TG was redesignated as the 37th Tactical Fighter Wing (TFW), consisting of the 415th Tactical Fighter Squadron (TFS), named the 'Nightstalkers', the 416th TFS, named the 'Ghostriders', and the 417th Tactical Fighter Training Squadron, the 'Bandits'.

Since being declared operational, the F-117A unit has maintained a number of aircraft on alert: alert aircraft carry no markings, their RAM finish is carefully touched up and all systems are checked. Although the aircraft are operated by Tactical Air Command, their operational use would be controlled at White House level. In fact, the aircraft had been ready to go to war on two occasions before mid-1986, but the missions were cancelled shortly before take-off.

The 37th TFW went into action on 19 December 1989 in support of the invasion of Panama. The type was selected for its accuracy, rather than its invulnerability. Six F-117As left TTR that night, operating in three pairs (primary and back-up), and flew non-stop to Panama with the aid of tankers. Two potential targets were eliminated from the list before the fighters arrived; the third,



Left: One of the two F-117As arrives at Nellis AFB for the type's public unveiling, 21 April 1990. The 37th TFW's base at Tonopah itself, and the F-117A flight test centre at Groom Dry Lake (also known as 'The Ranch', 'Dreamland', 'Area 51' or 'PS22') remain shrouded in secrecy. At a display for Caspar Weinberger at Groom Dry Lake, an F-117A was flown with a huge 'Stars and Stripes' painted over its belly.

Inset top: Most pilots for the F-117 have come to the aircraft from attack aircraft like the F-111, so are used to flying a large aircraft at low level. Aircrew are justly proud of serving in such an elite unit as the 37th TFW. Above: An F-117A is positioned for one of its first public displays, at the Andrews AFB 'Open House'. The huge flaps are shown to advantage.

Two F-117As at Tonopah. The F-117As differ in small details, since not all aircraft have been modified to the very latest standard. Some engine intakes differ quite noticeably, for example.

a field beside the Army barracks at Rio Hato, v attacked with laser-guided 2,000-lb bombs, c rupting Panamanian forces and paving the w for a ground assault. The accuracy of the attac still a matter for controversy – one bomb appe to have been aimed in the wrong place – but aircraft and their systems performed as they w intended.

Moving house

Under budget cuts announced in January 19 the 37th TFW is to move from TTR to Hollon AFB, New Mexico. Some new construction v be needed at Holloman, probably including dividual hangars, a secure operations buildi and a new RAM-respraying facility; work start in 1991, so the move will not take place u 1992 at the earliest.

Now that USAF purchases of the A-12 h been deferred, the F-117A will be the servi only low-observable deep strike aircraft until late 1990s at the very earliest. This may mak more likely that the aircraft will be improv possibly by the addition of radar and some air- air capability.

The F-117A is assured of a place in the histor military aviation, alongside other breakthro aircraft such as the Me 262 and SR-71. Have F proved that a stealth aircraft could and would Senior Trend showed that such an aircraft co perform an offensive mission. Starting from point, later designers such as the creators of B-2, the A-12 and the Advanced Tactical Fig prototypes developed new and probably m efficient stealth design techniques – but they co not have done it better, had the Skunk Wo team not done it first.

AIR WING SIX

As the first of a new class of 'supercarrier', USS *Forrestal*'s keel was laid down on 14 July 1952, and the ship commissioned on 1 October 1955. The first US carrier to be built with jets in mind, it featured an angled deck from the start. Despite a major fire disaster in July 1967 when the ship was launching strikes against Vietnam, *Forrestal* has survived to become one of the US Navy's most enduring ships. It is now a highly-active member of the Atlantic Fleet, although it has yet to receive Hornets in place of Corsairs.

Above, inset: USS **Forrestal** *is assigned to the US Navy's Atlantic Fleet, and is a regular visitor to Europe. Here it rides at anchor in the Solent while on a visit to Portsmouth.*

Right: Anti-submarine patrols away from the ship are undertaken by the Lockheed S-3A Viking. Air Wing Six's fixed-wing ASW squadron is VS-28.

Left: With engines at full power, a Grumman F-14A Tomcat strains at the leash. The catapult officer has signalled the launch, and within seconds the fighter will be airborne.

Above: First to leave the ship in any major airborne operation is the Grumman E-2C Hawkeye. It will make a long and slow transit out ahead of the carrier to watch for hostile aircraft.

Above: Immediately after landing, a Grumman A-6E Intruder taxis off the angled flight deck to clear it for aircraft landing behind. Its wings are beginning to fold so that it can be parked with the minimum of delay, thus taking up as little deck space as possible.

Below: The moment of truth arrives for this Vought A-7E Corsair II pilot, as he floats across the ramp, hopefully looking for a No. 3 wire. The aircraft carries an AGM-88 HARM anti-radiation missile under the wing, signifying a defence suppression sortie.

Above: Launching a large number of aircraft in a short time necessitates a large amount of organisation and maximum co-ordination between deck and air crew. Both bow cats are still steaming, yet this VF-11 'Red Rippers' F-14 is already lining up.

Below: Partnering VF-11 in the provision of air defence for the Forrestal is VF-31 'Tomcatters', whose 'Felix the Cat' squadron badge has adorned Navy fighters since between the wars. VF-31 is the dedicated TARPS pod-carrying Tomcat squadron.

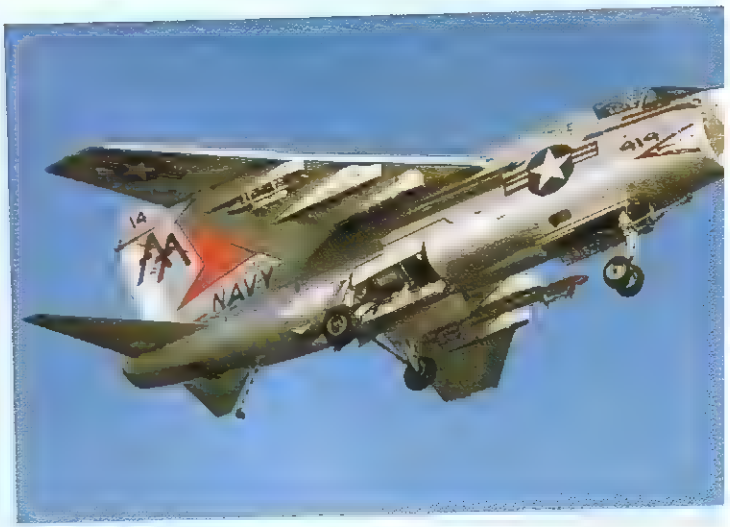
Above: To slow the Intruder down during the approach and trap, it has split wingtips which act as airbrakes. Thrust down from below the rear fuselage is the sturdy arrester hook, which will catch the wires before the main undercarriage touches the deck.

Left: Forrestal still retains Vought A-7Es in its two Light Attack squadrons, this aircraft being from VA-105. The LAt squadrons are in the process of changing to the F/A-18 Hornet, which provides greater versatility, better performance and enhanced air defence cover.

Right: In addition to the A-6E Intruders, the Medium Attack squadron (VA-176) also provides four KA-6D tanker conversions, distinguished by the permanent hose drum unit mounted in the rear fuselage. These aircraft are some of the last to adopt the low visibility grey colour scheme, and many give away their age and tanker tasking in their appearance. Additional tanker capacity can be provided by A-6Es and A-7Es equipped with 'buddy' refuelling pods.

Forrestal Flashback

This is how the *Forrestal*'s Air Wing looked 15 years ago, during a North Atlantic cruise in 1975. The bright colours of Navy aircraft in the 1970s make a refreshing change from the omnipresent grey of today. Phantoms were flying the fighter mission then, with VF-11 and VF-74, while the bulk of the Air Wing was using the same aircraft types as they do today. Attack was handled by Corsairs (VA-81 and -83) and Intruders (VA-85), while EA-6Bs, S-2s, SH-3s and E-2s provided support. Reconnaissance was handled by RVAH-7's Vigilantes.



Above: The A-7 first went to s during the Vietnam war, replacing A-4 Skyhawks on L Attack squadrons. During the 1970s most wore their markin loud and proud.

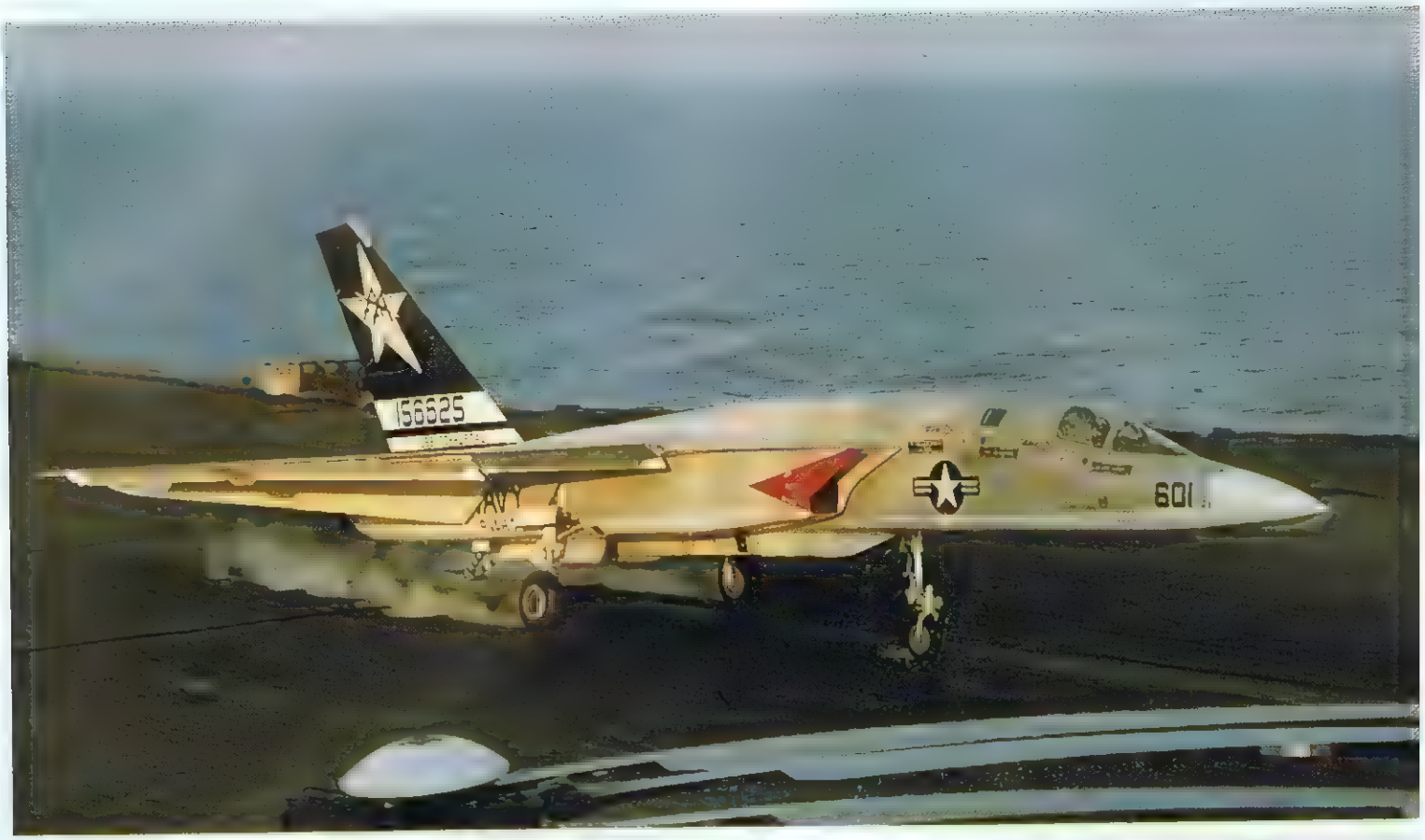
Right: A task now performed some specially-equipped Tomcats, carrierborne reconnaissance in the 1970s w the domain of the North American RA-5C Vigilante, t on Forrestal belonging to RVAH-7. The large 'canoe' fa under the fuselage contained cameras and a side-looking airborne radar, while the hun spine contained fuel.

Left: One of the most memo Navy aircraft, now disappea from US Navy service (apar a few test aircraft), the McDonnell F-4 Phantom wa employed by the two fighter squadrons aboard ship. VF- 'Be-Devillers' flew this F-4J Forrestal.

Right: With the hook firmly caught on the arrester wire, A-7E skips across Forrestal' flight deck. VA-83 was one carrier's two LAt squadrons other being VA-81.

Left: Currently partnering V in the Corsair squadrons is 37, characterised by the bul symbol on their tail. The LA bear the brunt of air strike and handle most of the defe suppression requirements, providing a secondary, if somewhat limited, air defe back-up.

Right: Hawkeyes are the l aircraft assigned to the Air and have to be more carefu most to be correctly aligne the approach to avoid hitti parked aircraft with their wingtips. VAW-122 'Steelja the E-2C from Forrestal, pr a wide range of airborne e warning and control capab



Above: In the 1970s, VF-11 flew F-4Js on air defence duties from Forrestal, and they still fly the same basic mission today, although now equipped with the F-14. The weapons used by the F-4J were the short-range Sidewinder and medium-range Sparrow missiles, also still in use today on the Tomcat.

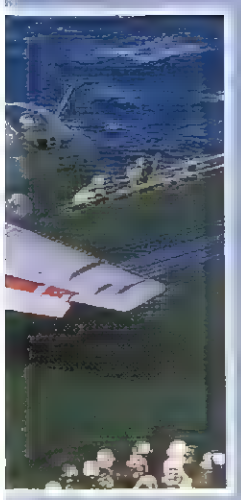
Above: While VS-28's Vikings go out on long-range ASW patrols, th Sikorsky SH-3H Sea Kings patrol the areas closer to the carrier. Serving with HS-15, this Sea King displays the towed MAD sensor the starboard side that is one of its main sensors. Both Sea King ar Viking can carry torpedoes and depth charges for attacking subs.

Right: A pair of EA-6B Prowlers and an A-6E Intruder bask in the sun during a respite from the stormy waters of the North Atlantic. Keeping the aircraft on deck during rough weather demands that they be securely chained to the many cleats that litter the entire deck area. Aircra washing is a major part of a sailor's life to keep the ever-present salt corrosion at bay.

Below: In keeping with the advances in modern warfare, the 'mini-air force' that the carrier takes to sea has to have sophisticated electronic countermeasures protection, supplied by the Grumman EA-6E Prowler. This four-seat derivatio of the Intruder has large receive antennas in the 'football' aerial on the fin top, which sense enemy radars. Onboard computers then direct the jammers to do their work to obliterate and deceive the hostil transmissions. The main jammers are carried in large poc under the wings and fuselage.

Above: Deck-hands watch nonchalantly as an EA-6B heads for a trap. VAQ-142 are the Prowler squadron on board Forrestal, and not only employ their aircraft to protect others on strikes but can be used to protect the carrier itself, and provide electronic intelligence.

Below: A Viking heads out into its environment to hunt for submarines. The aircraft is packed with sensors including sonobuoys, electronic support measures, radar and a retractable MAD boom, the end of which can be seen nestled in the tailcone.



The Bombers of
STRATEGIC

AIR COMMAND

An everlasting image of global power, a Strategic Air Command Boeing B-52H slides beneath a tanker. Although reduced in numbers from its heyday, the B-52 is still SAC's most numerous bomber after 35 years of service. Together with its younger counterparts, the Rockwell B-1 and General Dynamics FB-111, it shoulders the enormous responsibility of ensuring that no nation would ever dare to attack the United States for fear of the devastating retribution that these bombers could bring. On the horizon is a shape that is even more distinctive than that of the B-52, and one that will revolutionise the art of airborne deterrence: the Northrop B-2.

Purchased as an interim measure, the General Dynamics FB-111A is the 'baby' of the SAC fleet. Two wings were equipped with the type but these are now being converted to F-111G standard and handed over to Tactical Air Command.

Belching smoke, a B-52G hauls out on another long-range mission. SAC's huge tanker fleet allows the B-52 and B-1 to strike any point on the surface of the globe from their home bases.

On any SAC base, yellow domed lights are posted at intervals beneath a sign: STOP. PULL TO RIGHT. SAC ALERT. When flashing, it means B-1Bs, B-52s, FB-111As or tankers are scrambling aloft. First to go will be bombers on runway alert – newly washed down, checked for corrosives, armed up, ready.

If the klaxon sounds, if the yellow domed lights begin winking, the first of those alert B-52s can begin a MITO (minimum interval take-off) within minutes. They'll lift into the sky and fan out, scattering, each aircraft seeking to get out from the vortices of the aircraft in front and to escape from the base which is itself an obvious target for incoming ballistic missiles. While some may disperse to alternate airfields, most in the first wave will rush headlong into the transpolar war for which the Strategic Air Command (SAC) has prepared since its founding on 21 March 1946.

If the situation provided advance warning, many of the bombers will be off to dispersal fields, confounding Soviet hopes to 'get' them with a first strike by ballistic missiles. Th tankers will be in the air in short order, too, each part of thi armada rushing into its wartime function as orchestrated i the American scheme for all-out war, the SIOP (Single In tegrated Operations Plan). In peacetime, a 'SIOP missio has become slang shorthand for a practice mission with sim ulated nuclear weapons.

Military men prepare to confront an adversary based o his capabilities, since they cannot discern his intentions. No even SAC's 544th Strategic Intelligence Wing, a special un that reports to nobody else but the boss, can tell us what th Russians think. No matter how Soviet politics are restru tured or what happens in Eastern Europe, the Soviets hav never been militarily more ready for all-out, transpol nuclear war.

SAC's mission is to prevent the unthinkable by deterrin it. SAC people believe in that corny old phrase whic General Curtis E. LeMay posted on SAC bases as part of a r enlistment campaign, beginning December 1957: PEACE I OUR PROFESSION.

New motto for a new world

This didn't prevent an official change on 25 January 199 announced publicly the following month. Now, SAC's offi cial motto is "War is our profession – peace is our product

In LeMay's era, SAC was the greatest air armada the wor had ever known, at one point in the late 1950s equipped wi as many as 2,600 bombers. In the 1990s, it was judged th SAC's job could be performed by just 346 bombers, aggregate that included 157 B-52Gs (of 193 built), 93 B-52H (of 102 built) and 95 B-1Bs (of 100 built and 97 extant). Pe haps, too, it was partly not so much judgement as the resu of arbitrary decisions over many years, but the result r mained: 346 bombers.

Not included in this figure are SAC's 48 FB-111A aircraft (of 58 existing airframes). By early 1990, these were well advanced towards being transferred to the tactical air forces.

This SAC bomber force is one-third of the strategic triad. It has been American doctrine since the early 1960s that the strategic force confronting the Soviet Union should have three legs – the bomber force, the US Navy's SLBM fleet (submarine-launched ballistic missiles) and the land-based ICBM (intercontinental ballistic missile) force, which also belongs to SAC.

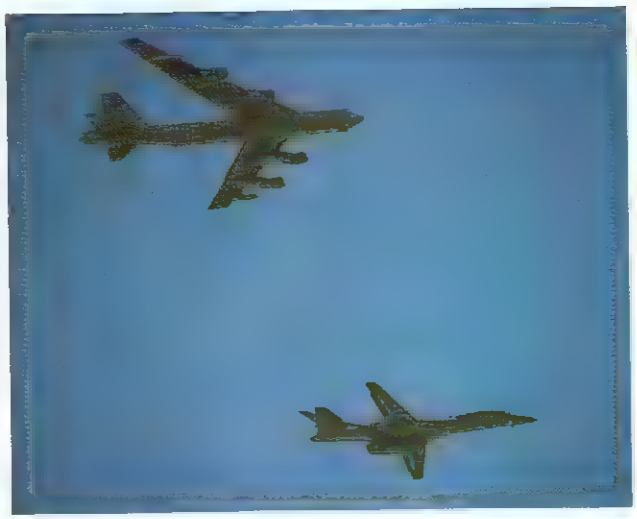
The SIOP is so secret even most people with top secret clearances cannot see it. The SIOP is the national plan for employment of nuclear forces against the Soviet Union in the first hours of war. The SIOP determines targets, prescribes measures to overcome Soviet defence of those targets, establishes the order in which targets shall be attacked, and choreographs every detail of the attack by bombers, SLBMs and ICBMs.

Though the plan is computerised, a SAC insider emphasises that it is developed by people and that it relies on the arcane skill of weaponeering – determining what kind of bomb, missile, or warhead is right for a given target under a given set of circumstances. One purpose of the plan is to prevent fratricide, the destruction of some US nuclear weapons by other US nuclear weapons.

The SIOP has been described as a large spreadsheet or matrix of Soviet targets overlaid by the number and type of weapons needed to wipe them out. In 1989, President Bush signed the current version, SIOP-6G, aimed not at Soviet cities but at Soviet nuclear and conventional forces ('counter-

Left: Ninety-five Rockwell B-1Bs form the spearhead of the SAC force, posing severe problems for an defences they may be sent up against. Although not true 'stealth' aircraft, their radar cross-section makes detection difficult, particularly during the high-speed, low-altitude penetratio that is their forte. Wher the B-2 becomes available, the B-1B will revert to the stand-off missile-launching role.

The Bombers of Strategic Air Command



A graphic illustration of the advancement of aviation technology is provided by this B-52G flying alongside a B-1B. The new aircraft is much smaller, yet it can carry a similar weapon load over a similar range but at far greater speeds and much reduced vulnerability. Both of these aircraft serve with the 6512th Test Squadron at Edwards AFB, California, retained for trials purposes (along with a B-52H).

force', in nuclear war jargon) and at command centres and hide-aways of Soviet leaders ('decapitation').

It's likely that the SIOP gives the SAC bomber force the most difficult targets – including mobile, relocatable targets such as railway-garrisoned Soviet ICBMs. The submarine missile force is the leg of the triad least vulnerable to enemy action but is also the least accurate, its missile warheads usable against easier targets such as large installations or cities. The land-based ICBM force, which belongs to SAC, is more accurate and can strike medium-difficulty targets such as the Soviets' hardened ICBM silos.

Only one leg of the triad, the SAC bomber armada, can be re-directed or recalled after launch, can 'chase' a target (such as an ICBM railway train) and can be dispersed to other bases for future use, including that unthinkable second day of the war. SAC bombers can also perform conventional bombing and maritime projection missions, though the SIOP is their *raison d'être*.

The decision to go to war, to put the SIOP into effect, to launch SAC bombers is made by the National Command Authority, or NCA.

Deterrence in action! The urgency of the word 'alert' bears little resemblance to a B-52 resting in the snow on a cold, wintry day in the central United States. Yet don't be fooled – within minutes of the klaxon going off, the bomber and its precious clutch of cruise missiles will be airborne and pursuing its deadly business. The armed guard is there to ensure that nobody gets in its way.

Chain of command

NCA begins with the President, goes next to the Secretary of Defense – in 1990, Richard T. (Dick) Cheney – and continues to the American field commanders, who are known in jargon as CINCs (pronounced "sinks," for commanders-in-chief). Not included in this chain of command on the nuclear trigger are the Vice President, Congress, and the many generals and admirals who are not CINCs. Unlike countries whose armed forces are headed by a General Staff, the United States' most senior officers, the Joint Chiefs of Staff, are not part of the NCA chain and do not command forces.

The CINC who oversees two-thirds of the strategic triad is CINCSAC, or commander-in-chief, Strategic Air Command – in 1990, General John T. (Jack) Chain.

SAC's bomber force is small and old. It is also, in the official view of the US Air Force, less effective than is generally understood. The USAF's official position is that the Rockwell B-1B bomber, currently 95 airframes in four bomb wings, is the only aircraft capable of penetrating Soviet defences to deliver ordnance to Soviet targets. The Boeing B-52G/H Stratofortress, currently 250 airframes (minus 46 B-52Gs allocated to conventional and maritime operations) in 11 wings is officially a stand-off weapon armed with ALCMs (air-launched cruise missiles).

SAC views the B-1B as its principal penetrator, also employs the B-52H for some penetration missions, but is fearful that before long the B-52 will no longer be able to penetrate Soviet airspace and will be relegated to the stand-off role. Today, B-52 crews still practise penetrating Soviet defences and none will admit that there's any job the B-52

Strategic Air Command's ability t get at the heart of a nation has risen gre with the arrival of th Rockwell B-1B. At present tasked with penetration role, the B-1B combines high speed with a superb degree of agility at l level for such a larg beast. Terrain-follow radar and the variab geometry wing allow safe and comfortabl cruise through defe areas while still carrying sufficient f and weapons to ma long and effective s deep into hostile territory.

Below: The FB-111A tasked in SAC serv with high-accuracy strikes against sma targets, principally enemy defences so the larger bombers continue their deep strikes unhindered primary weapon fo such missions is th Boeing SRAM (Sh Range Attack Miss but the FB-111 retai conventional capa as evidenced here these 509th Bomb W aircraft.

can't perform. Says pilot Major Brian C. (Buck) Rogers, "With a tanker, I can get to anywhere from Ellsworth [air force base in South Dakota] and put 51 of those babies [conventional bombs] or 24 nukes on targets."

Strategic Air Command's top brass take fierce pride in keeping up a fully-integrated force so that each SAC unit, decreasing in size as we proceed down the organisation chart, is by itself a kind of mini-SAC. It might seem tempting to station only tankers at one base, only bombers at another, or to place all nuclear bombers under one commander and all conventional bombers under another. Certainly the steep cost of running SAC could be lowered if aircraft of the same type were bunched together or if each of the two numbered air forces had only one mission. But SAC isn't willing to have things this way.

Integrated organisation

If the lower-cost, specialised method of organisation were adopted, the SAC force would be rather like a man who can be struck in any of several locations – head, heart, groin – and totally disabled with a single blow. This would happen, for example, if all tankers were concentrated at a few bases and a Soviet nuclear strike disabled most of them. Air bases untouched by a nuclear strike would be nothing more than

When fully-laden, the B-52G uses water injection to its eight Pratt & Whitney J57 turbojets to provide some vital additional thrust on take-off. The water injection also produces excruciating noise and huge clouds of black smoke, obscuring the runway for following aircraft. During a MITO (Minimum Interval Take-Off), when several aircraft launch one after the other, the airfield is literally obliterated from view!

parking lots, filled with useless bombers unable to refuel aloft and so prevented from bombing anything.

With its costlier integrated organisation – for example, with more wings equipped with both tankers and bombers – SAC is less like a vulnerable man and more like a Hollywood horror film's seething blob of ectoplasm: destroy or cut off one part of this monster, and other parts survive. Put a 10-megaton airburst over one SAC base, and the bombers and tankers from another base will live to fight back.

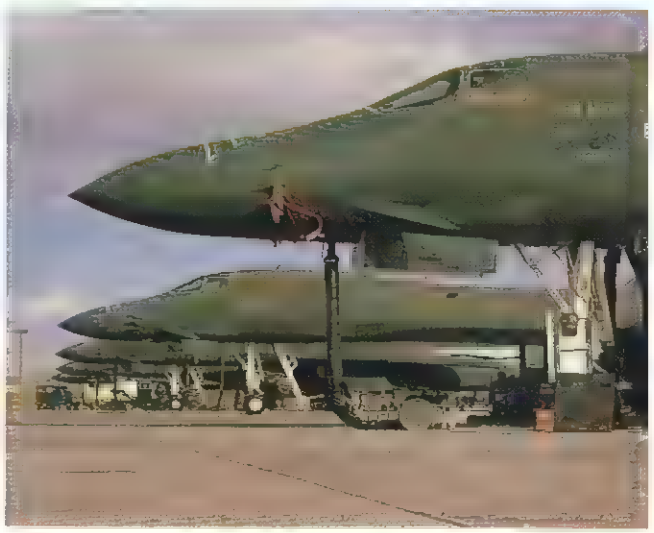
At SAC headquarters – the sandstone-coloured structure known as Building 500 atop a hillock at Offutt AFB outside the one-time cow town of Omaha, Nebraska – the underground CP (command post) beneath the front lawn is "well protected against the tornadoes we get in the mid-west," says an Air Force major, "but if Jack Chain want to breathe after the first minutes of the war he'd better get his butt on Looking Glass" – an EC-135C airborne command post, one of which is airborne while a second is on alert at Offutt at all times.

From SAC headquarters the next step down the "wiring diagram," as Air Force officers call an organisation chart, takes us to SAC's two numbered air forces.

Eighth Air Force is based at Barksdale AFB, Louisiana, beside the bayou backwater of Bossier City, and is commanded by Lieutenant General Ellie G. Shuler, Jr; Fifteenth Air Force is at March AFB near Los Angeles and commanded by Lieutenant General Robert D. Beckel. They are fully integrated, just as is SAC itself. An anomaly is the strategic reconnaissance community, operating U-2, TR-1 and RC-135 aircraft, all of which fits under Fifteenth Air Force.

Each air force has bombers, tankers and missiles. Each has conventional and nuclear missions. Eighth Air Force has more aircraft, and Fifteenth more of the ICBMs which are outside the scope of this report.

To make sure its bombers do the job, SAC's 99th Strategic Weapons Wing at Ellsworth AFB, South Dakota, will have its Strategic Warfare Center (SWC), the 'schoolhouse', fully operational in 1992. The wing and the future SWC will include a Strategic Training Center (STC), operated by its 25th Strategic Training Squadron. Every crew in the command will visit the STC annually for a week, or will undergo three flights plus academic training, all aimed at improving bomber crew proficiency.

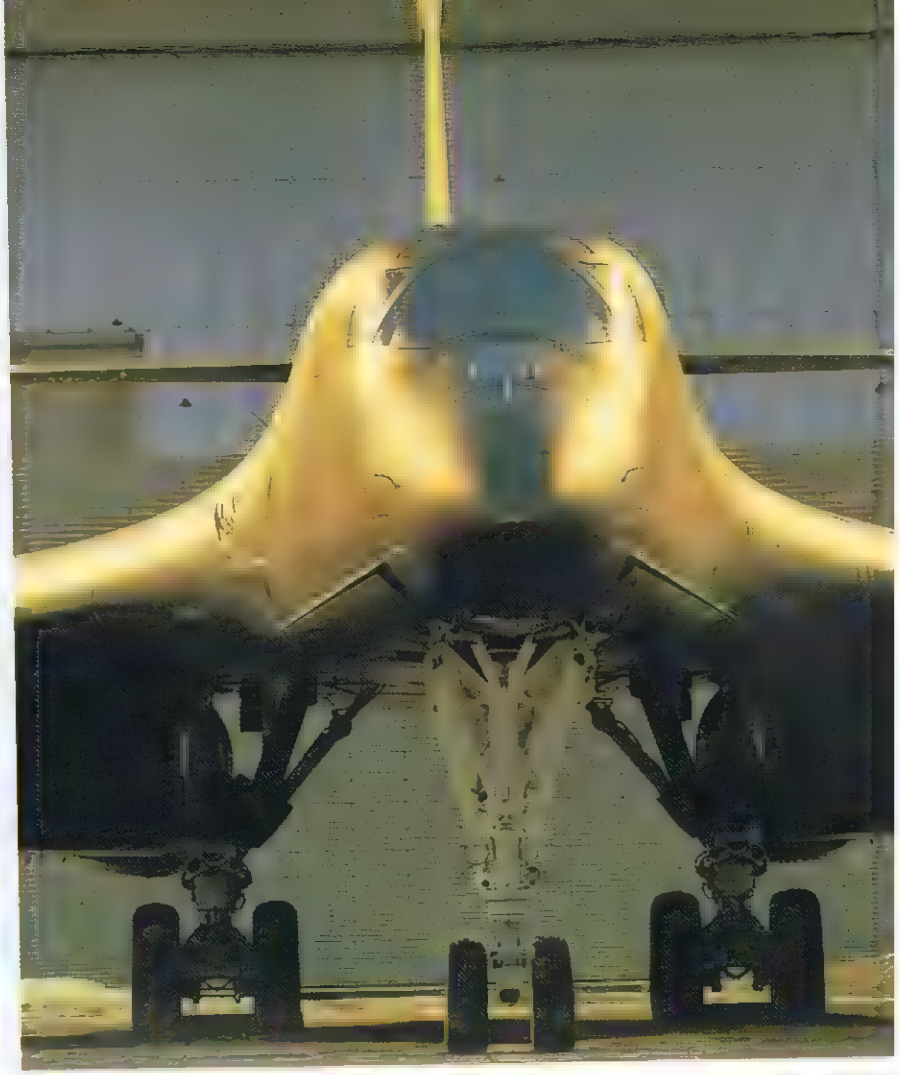


Far right: Rockwell B-1Bs of the 28th Bombardment Wing line up at their base at Ellsworth AFB, South Dakota. SAC has authorised the return of nose arts to its bomber and tanker fleets, many of which having been derived from those carried by B-17s, B-24s and B-29s during World War II, although 'Low Level Devil' is strictly a modern design.

SAC school

Also included in SWC is the Strategic Weapons School (SWS). This is SAC's 'Top Gun' school, not intended for every crew but viewed as a kind of 'PhD' school with 12 carefully selected candidates per class. It's 11 weeks long and has 200 hours of academics and 15 flights, covering the entire spectrum of bomber operations.

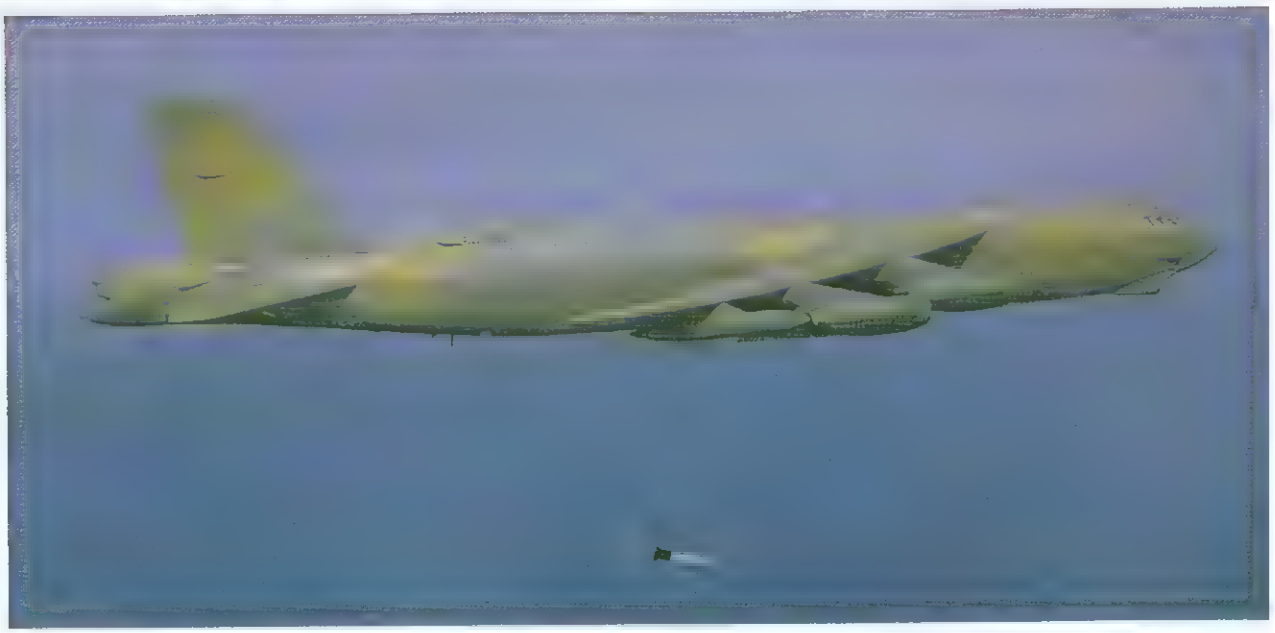
Although "sorely underfunded," as one expert puts it, SWC provides essential training to bomber crews who come on TDY (temporary duty) from other bases to wring out their warplanes over a vast complex, the Strategic Range Training Complex, which sprawls over Wyoming, Montana and South and North Dakota and is brimming with real-life 'threats', including Soviet radar emitters.



Above: The current state-of-the-art as far service strategic bombers go is the Rockwell B-1B, the distinctive blended shape having benefic effects on its radar cross-section. The moustache-like vanes either side of the nos are controlled by the complex flight contro system to smooth the aircraft's ride, reduci both crew and structu fatigue.

The shape of things come: the Northrop 'stealth' bomber is a but invisible to exist air defence radars, allowing it to pass through to its target undetected. With the thawing of East-Wes relations, many are questioning the nee such a costly and sophisticated weapo

Above: A SAC crew guides its B-52 through a low-level training sortie. On a real nuclear mission the crew would be flying 'zipped-up', with blast shields across the glazed panels. Terrain avoidance radar and the EVS (Electro-optical Viewing System) would be used for navigation and targetting.



Right: The impressive range and load-carrying ability of the B-52G made it a natural for maritime operations, and in recent years some wings have picked up this task. This aircraft is seen sowing a mine.

The Rockwell B-1B is the principal SAC bomber of the 1990s. It equips four first-line bombardment wings and, it must be assumed, bears the most difficult portion of the SIOP burden assigned to the manned bomber force. One hundred B-1Bs were built. Three had been lost in crashes by 31 March 1990. Two are assigned for test work to Air Force Systems Command (AFSC) at Edwards AFB, California. The remaining 95 belong to SAC.

The breakdown of B-1B assignments by base shows 33 at Dyess, 30 at Ellsworth, 16 at Grand Forks and 16 at McConnell. Given routine maintenance considerations, the number of B-1Bs available to participate in combat on any given day is probably of the order of 80.

The B-1B impressed people with its black and sinister looks. In fact, the aircraft is two shades of dark grey and one of green. One SAC B-1B pilot describes his bomber as "a nifty, hi-tech equivalent of an afternoon in a videogame arcade."

This is misleading. The B-1B is serious in purpose. Wit its long development history, the production B-1B rolled ou of the factory already optimised for its role in an atomic wa Although flying at high speed and terrifyingly low altitude at times as low as 50 ft (15 m) to evade enemy radar – the B-1 crew can be as detached from the outside world as, say, me in a submarine or space ship.

The four-man crew flies the B-1B 'zipped up', shielde from thermonuclear flash-blindness by thermal blast curtai into which are placed six portholes equipped with PLZ (polarised lead zercomnium titanate, known to crews as 'pl zit'), reducing external light to .003 per cent of its original in tensity.

The crew includes the pilot (also known as aircraft com mander, or AC), co-pilot, offensive systems operator (who a navigator), and defensive systems operator. Many B-1 pilots now fly the bomber as their first and only aircraft typ having come into it directly from UPT (undergraduate pil

training).

Pilot and co-pilot are side-by-side facing forwards and have an instrument panel that includes a mixture of digital and analog instruments – each having a large, multi-mode CRT (cathode ray terminal). Outside critics have said the B-1B should have a HUD (head-up display). Even when windshield and windows aren't covered, pilots don't often make much use of external visual cues, relying instead on terrain-following technology, but some pilots have said, too, that a HUD would be useful. A modest MSIP (multi-stage improvement programme) for the B-1B for the early 1990s still does not include this feature.

Systems operators

Offensive systems operator and defensive systems operator also sit side by side behind the pilots, also facing forward. Both have work stations dominated by CRTs. The offensive systems operator carries out most of the tasks traditionally associated with navigator and bombardier, and gets the bomber to and from its target. The defensive systems operator protects the B-1B, which has no defensive armament, using a defensive avionics system that utilises the AN/ALQ-161 electronic countermeasures (ECM) system. Development of an ECM system to foil Soviet detectors has not been without difficulty, but the system is functioning now, notwithstanding the claim of one Washington critic that the B-1B is "the world's first self-jamming bomber."

The crew of the B-1B sit in Douglas-designed, Weber-built ACES II (Advanced Concept Ejection Seats) that have zero-zero capability and eject vertically through egress ports left by dorsal hatches which jettison when the bail-out sequence is initiated.

The smooth contours of the B-1B give it some claim to the title 'stealth' bomber in its own right. The fuselage blends into the wing, creating a low-drag configuration. The B-1B is thought to have a radar cross-section (RCS) about one-fourth that of a B-52 although not, as one USAF release claims, 1/100th.

Power comes from four 30,000-lb static thrust General Electric F101-GE-102 turbofan engines. The internal nuclear warload can be eight AGM-69A SRAM (Short-Range Attack Missiles), B-83 or B-61 nuclear bombs. In SAC operations, the B-1B does not at present carry the AGM-86B ALCM (air-launched cruise missiles) and is not scheduled for the AGM-129 ACM (advanced cruise missile), although eight ALCM can be accommodated after ground crews reposition the bulkhead of the B-1B's bomb bay. The B-1B also is not routinely assigned conventional duties, but in a conventional role it is capable of carrying up to 84 500-lb (227-kg) Mk 82 or 24 2,000-lb (907-kg) Mk 84 bombs internally.

On the ground the B-1B looks cumbersome, its spindly undercarriage and high aspect ratio wings giving it an ungainly look. However in flight with its wings fully-swept it takes on much sleeker, more purposeful look. In the inset aircraft from the 319th Bomb Wing taxi for a mission while below a production aircraft cavorts over the California desert near the Palmdale factory.


U.S. AIR FORCE
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Left: Unlike previous strategic bombers, the B-1B is not averse to pulling some 'g'. In moist air, a characteristic cloud is formed during hard turns and pull-ups.

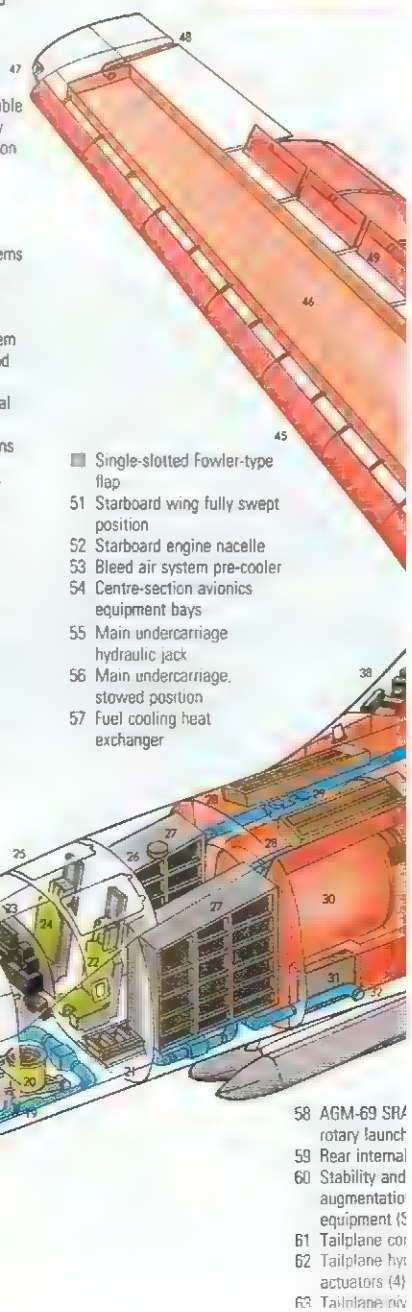
Below left, inset: Strategic bombers are by nature solitary beasts. This rare pair of B-1s approaches a tanker during refuelling training.

Below: SAC tankers are co-located with every bomber unit, and a number of others besides. Although their primary function is to refuel the bombers, their talents are also widely appreciated by TAC and MAC aircraft. This KC-135R/B-1B combination are both from the 28th Bomb Wing at Ellsworth.

Above: Viewed from beneath on take-off, the B-1B shows clearly its three weapon bays and full-span leading-edge slats.

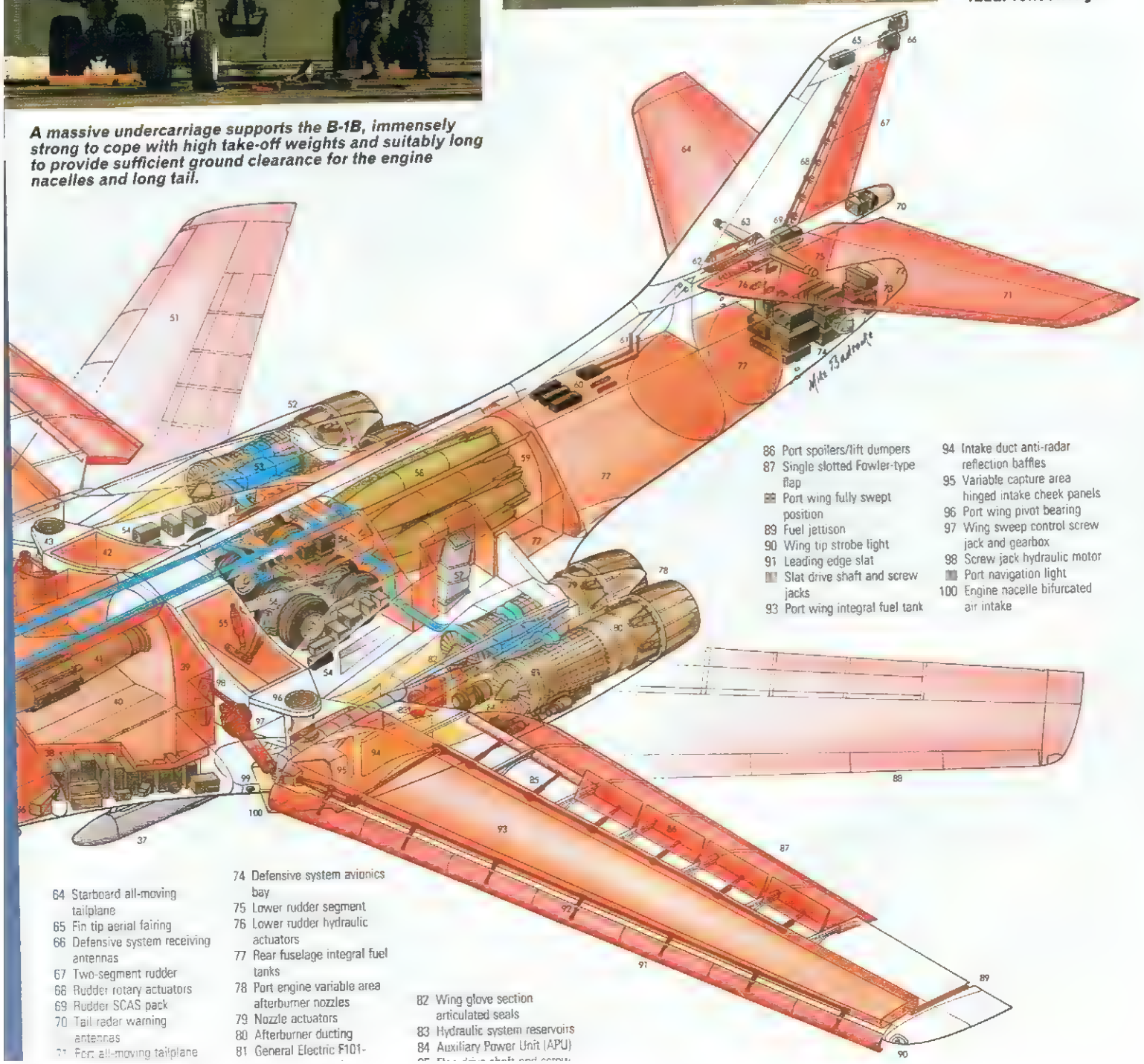
Rockwell B-1B cutaway key

1 Radome
2 Multi-mode phased array radar antenna
3 Low observable shrouded scanner tracking mechanism
4 APQ-146 offensive radar equipment bays
5 Pitot heads
6 Foreplane hydraulic actuator
7 Structural mode control system (SMCS) foreplane
8 Nose undercarriage, stowed position
9 Control column
10 Rudder pedals
11 Flight refuelling receptacle
12 Windscreen panels
13 Fully shrouded instrument panel
14 Cockpit roof escape hatches, all positions
15 Co-pilot's station
16 Weber 'ACES' zero-zero ejection seats, all positions
17 Pilot's station
18 Side console panel, engine throttle and wing sweep controls
19 Conditioned air ducting
20 Toilet
21 Ventral entry hatch and folding ladder
22 Defensive systems operator's station (DSO)
23 Systems operator's instrument console
24 Offensive systems operator's station (OSO)
25 Cabin roof escape hatches
26 Astro navigation antenna
27 Main avionics equipment racks, port and starboard
28 Chaff/flare dispensers
29 Air system ducting and control valves
30 Weapons bay extended range fuel tank, detachable
31 Electrical equipment bay
32 Ground cooling connection
33 Weapons bay movable bulkhead
34 Bomb doors
35 Retractable spoiler
36 Defensive avionics systems transmitting antenna
37 ALCM external carriage, maximum 14
38 Defensive avionics system equipment bays, port and starboard
Forward fuselage integral fuel tanks
40 Forward internal weapons bay
41 Rotary weapons carrier/dispenser
42 Wing pivot box integral fuel tank
43 Wing pivot bearing
44 Starboard wing sweep control jack
45 Leading edge slat
46 Starboard wing integral fuel tank
47 Wing tip strobe light
48 Fuel jettison
49 Starboard spoilers/lift dumpers
Single-slotted Fowler-type flap
51 Starboard wing fully swept position
52 Starboard engine nacelle
53 Bleed air system pre-cooler
54 Centre-section avionics equipment bays
55 Main undercarriage hydraulic jack
56 Main undercarriage, stowed position
57 Fuel cooling heat exchanger
58 AGM-69 SRA rotary launch
59 Rear internal
60 Stability and augmentatio equipment (S
61 Tailplane co
62 Tailplane hy actuators (4)
63 Tailplane piv



A massive undercarriage supports the B-1B, immensely strong to cope with high take-off weights and suitably long to provide sufficient ground clearance for the engine nacelles and long tail.

A nose close-up during refuelling reveals the SMCS foreplanes, six air data probes clustered each side of the nose and the open refuelling receptacle with its attendant guide marks. When not in use, a door slides over the fairing to reduce drag. The gold-tinted glass of the windscreen is reputed to reduce radar reflectivity.



64 Starboard all-moving tailplane
65 Fin tip aerial fairing
66 Defensive system receiving antennas
67 Two-segment rudder
68 Rudder rotary actuators
69 Rudder SCAS pack
70 Tail radar warning antennas
71 Port all-moving tailplane
74 Defensive system avionics bay
75 Lower rudder segment
76 Lower rudder hydraulic actuators
77 Rear fuselage integral fuel tanks
78 Port engine variable area afterburner nozzles
79 Nozzle actuators
80 Afterburner ducting
81 General Electric F101-
82 Wing glove section articulated seals
83 Hydraulic system reservoirs
84 Auxiliary Power Unit (APU)
86 Port spoilers/lift dumpers
87 Single slotted Fowler-type flap
88 Port wing fully swept position
89 Fuel jettison
90 Wing tip strobe light
91 Leading edge slat
92 Slat drive shaft and screw jacks
93 Port wing integral fuel tank
94 Intake duct anti-radar reflection baffles
95 Variable capture area hinged intake cheek panels
96 Port wing pivot bearing
97 Wing sweep control screw jack and gearbox
98 Screw jack hydraulic motor
99 Port navigation light
100 Engine nacelle bifurcated air intake

The B-52 is officially a stand-off weapon, but its crews train and rehearse as if they were anything but SA 'second-string' bomber. The B-52 in service with SAC at outset of the 1990s is far different from that envisaged w the B-52 was designed in the 1940s. The wing is stiffer, tail shorter, the fuselage identical on the outside but diffe inside – within their cavernous interiors the B-52G B-52H of today are new aircraft.

Designed for visual, high-altitude warfare with large gr ity bombs, the B-52 now goes to war 'zipped up', all wi shields covered by aluminised fabric/Velcro blast curtains tree-top level using the AN/ASQ-151 electro-optical view system (EVS), forward-looking infra-red (FLIR), and l light television (LLTV), carrying smaller and slimmer B B83 nuclear bombs and/or SRAM or ALCM missiles.

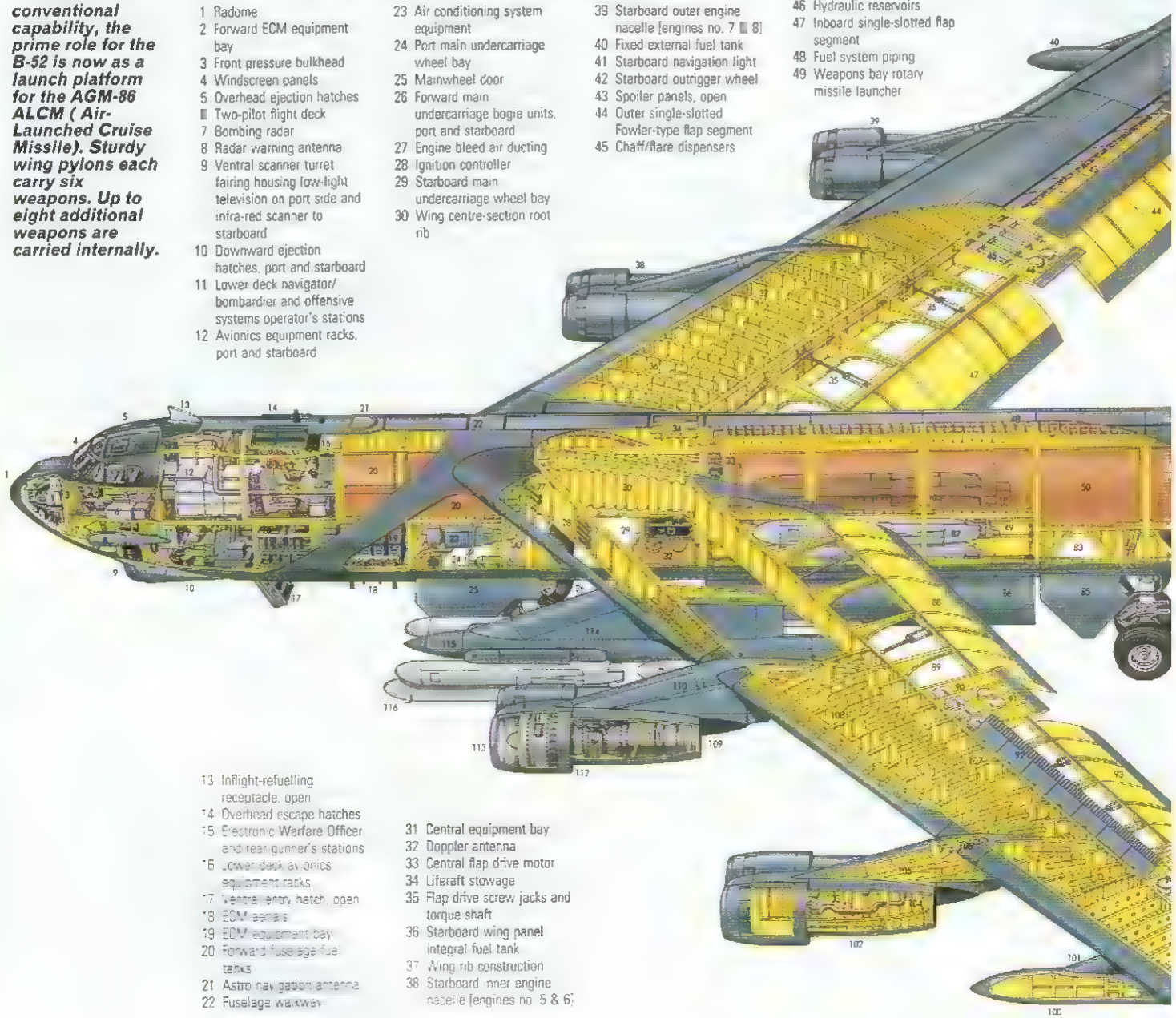
The Strategic Air Command's B-52 force consists B-52G and B-52H aeroplanes, all earlier versions hav been retired. B-52G models have 13,750-lb (6237-kg) th water-injected Pratt & Whitney J57-P-19W turbojets, w B-52H aeroplanes have 17,000-lb (7711-kg) thrust Prat Whitney TF33-P-1 or -3 turbofans.

Says B-52H pilot Lieutenant-Colonel Larry Nilssen, "'

Although it retains free-fall nuclear and conventional capability, the prime role for the B-52 is now as a launch platform for the AGM-86 ALCM (Air-Launched Cruise Missile). Sturdy wing pylons each carry six weapons. Up to eight additional weapons are carried internally.

Boeing B-52H Stratofortress cutaway key

1 Radome
2 Forward ECM equipment bay
3 Front pressure bulkhead
4 Windscreen panels
5 Overhead ejection hatches
6 Two-pilot flight deck
7 Bombing radar
8 Radar warning antenna
9 Ventral scanner turret fairing housing low-light television on port side and infra-red scanner to starboard
10 Downward ejection hatches, port and starboard
11 Lower deck navigator/bombardier and offensive systems operator's stations
12 Avionics equipment racks, port and starboard
13 Inflight-refuelling receptacle, open
14 Overhead escape hatches
15 Electronic Warfare Officer and rear gunner's stations
16 Lower deck avionics equipment racks
17 Ventral entry hatch, open
18 ECM aerials
19 ECM equipment bay
20 Forward fuselage fuel tanks
21 Astro navigation antenna
22 Fuselage walkway
23 Air conditioning system equipment
24 Port main undercarriage wheel bay
25 Mainwheel door
26 Forward main undercarriage bogie units, port and starboard
27 Engine bleed air ducting
28 Ignition controller
29 Starboard main undercarriage wheel bay
30 Wing centre-section root rib
31 Central equipment bay
32 Doppler antenna
33 Central flap drive motor
34 Liferaft stowage
35 Flap drive screw jacks and torque shaft
36 Starboard wing panel integral fuel tank
37 Wing rib construction
38 Starboard inner engine nacelle (engines no. 5 & 6)
39 Starboard outer engine nacelle (engines no. 7 & 8)
40 Fixed external fuel tank
41 Starboard navigation light
42 Starboard outrigger wheel
43 Spoiler panels, open
44 Outer single-slotted Fowler-type flap segment
45 Chaff/flare dispensers
46 Hydraulic reservoirs
47 Inboard single-slotted flap segment
48 Fuel system piping
49 Weapons bay rotary missile launcher



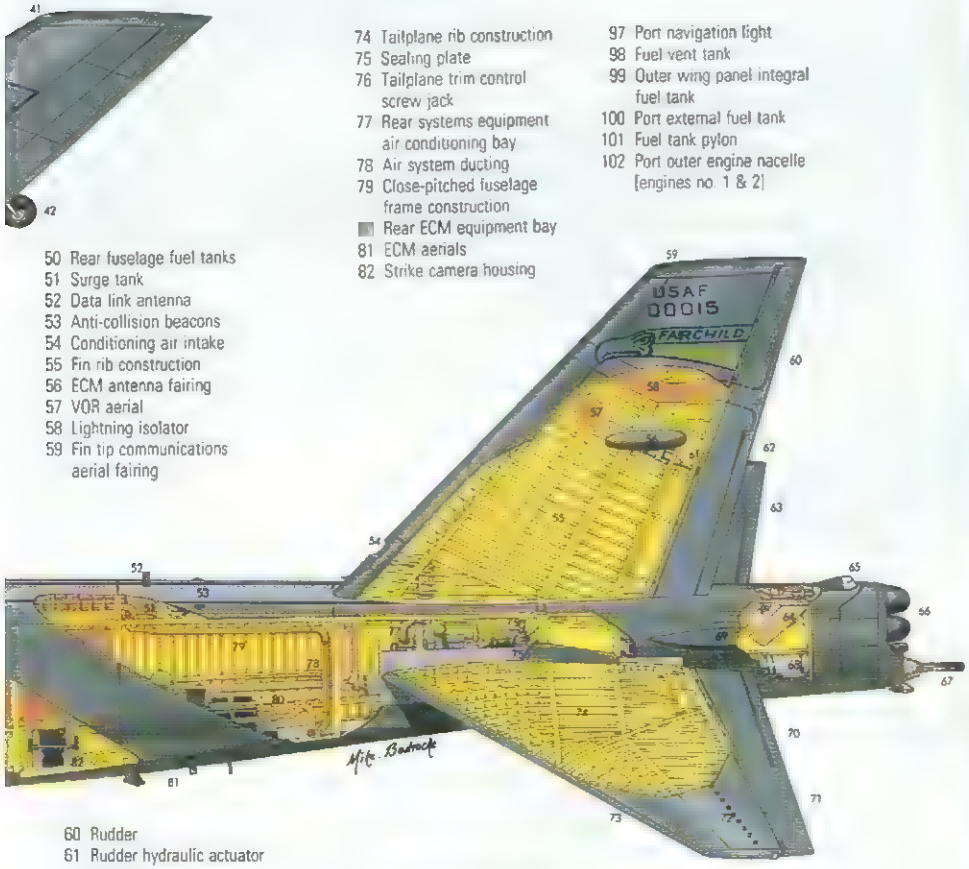
no-fuel landing weight of an H model is about 180,000lb, so the combined thrust of 136,000lb is very healthy indeed. In fact, we sometimes exaggerate and say the H model has a thrust-to-weight ratio of 1:1. If you're flying light, you can approach 12,000 feet rate of climb on the VVI (vertical velocity indicator)."

The difference in powerplants between G and H models is significant. With the KC-135 tanker fleet gradually converting to other engines, the ageing J57 is becoming more difficult to support. An epoch-making powerplant in the 1950s, it is now viewed as an anachronism; the clouds of black smoke coughed up by the eight-engined B-52G when water injection is used must be seen to be believed!

Less well-known is that the feature cannot be used below 40 degrees Fahrenheit, or induction freezing will result – and many B-52G bases are in locations that have bitter cold winters. Preparing for spring includes flushing out the water system on the G model.

Another pilot describes a water-injected take-off this way: "The idea of dumping tons of water into a fire is as absurd as it sounds. If the pumps don't work or you lose the water augmentation, conditions can become critical. What can also

The open doors and slipway of this B-52's refuelling receptacle beckon the boom of the KC-135 tanker. Although the bomber's fuel system can accept the full rate of flow offered by the tanker's four pumps, the bomber can stay hooked up for over 15 minutes during a large transfer of fuel, placing considerable strain on both crews if the air is turbulent. Tanker and bomber crews also have to practice refuelling during high angle turns, with up to 45° bank.



50 Rear fuselage fuel tanks
51 Surge tank
52 Data link antenna
53 Anti-collision beacons
54 Conditioning air intake
55 Fin rib construction
56 ECM antenna fairing
57 VOR aerial
58 Lightning isolator
59 Fin tip communications aerial fairing

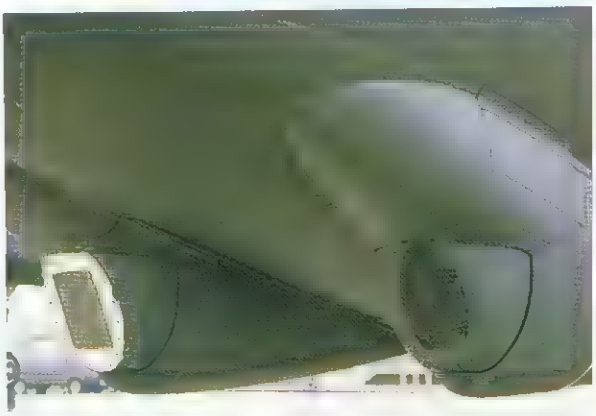
74 Tailplane rib construction
75 Sealing plate
76 Tailplane trim control screw jack
77 Rear systems equipment air conditioning bay
78 Air system ducting
79 Close-pitched fuselage frame construction
Rear ECM equipment bay
81 ECM aerials
82 Strike camera housing

97 Port navigation light
98 Fuel vent tank
99 Outer wing panel integral fuel tank
100 Port external fuel tank
101 Fuel tank pylon
102 Port outer engine nacelle [engines no. 1 & 2]

60 Rudder
61 Rudder hydraulic actuator
62 Trim tab
63 Starboard trimming tailplane
64 Brake parachute housing
65 Radar warning antenna
66 Gun control radar antennas
67 M61A-1 20-mm rotary cannon
Ammunition drum
69 ECM transmitting antenna
70 Elevator trim tab
71 Port elevator
72 Vortex generators
73 Port trimming tailplane

83 Rear undercarriage wheel bays
84 Main undercarriage bogie units, port and starboard
85 Mainwheel door
86 Bomb doors, open
87 Internal cruise missile carriage, eight on rotary launcher
Port inboard flap segment
89 Flap guide rails
90 ECM dispensers
91 Hydraulic reservoirs
92 Roll control spoiler panels
93 Outboard slotted flap segment
94 Hydraulic equipment bay
95 Outrigger wheel bay
96 Fixed portion of trailing edge

103 Engine bay dividing firewall
104 Bleed air ducting
105 Nacelle pylon construction
106 Pylon attachment joint
107 Port wing rib construction
108 Wing integral fuel tank
109 Engine exhaust nozzle fairing
110 Inboard nacelle pylon
111 Pratt & Whitney TF33-P-3 turbofan engine
112 Fan air exhaust duct
113 Inboard engine nacelle [engines no. 3 & 4]
114 Underwing weapons pylon, port and starboard
115 Six-round missile carrier
116 AGM-88B cruise missiles



Above: A characteristic addition to the B-52 airframe are twin blisters under the nose for the EVS. These comprise forward-looking infra-red (starboard) and low light level (port). Controlled by the radar navigator, these sensors a used to display an image on cockpit consoles in front of two pilots and two navs. The pilot consoles also have th terrain avoidance trace and steering commands superimposed, while vital information such as airspeed, radio altimeter reading and the 'time-to-go' for bombing runs. When not in use, the EVS sensors rotate into the blisters for protection, while the optical windscreens hav inflight washing capability.

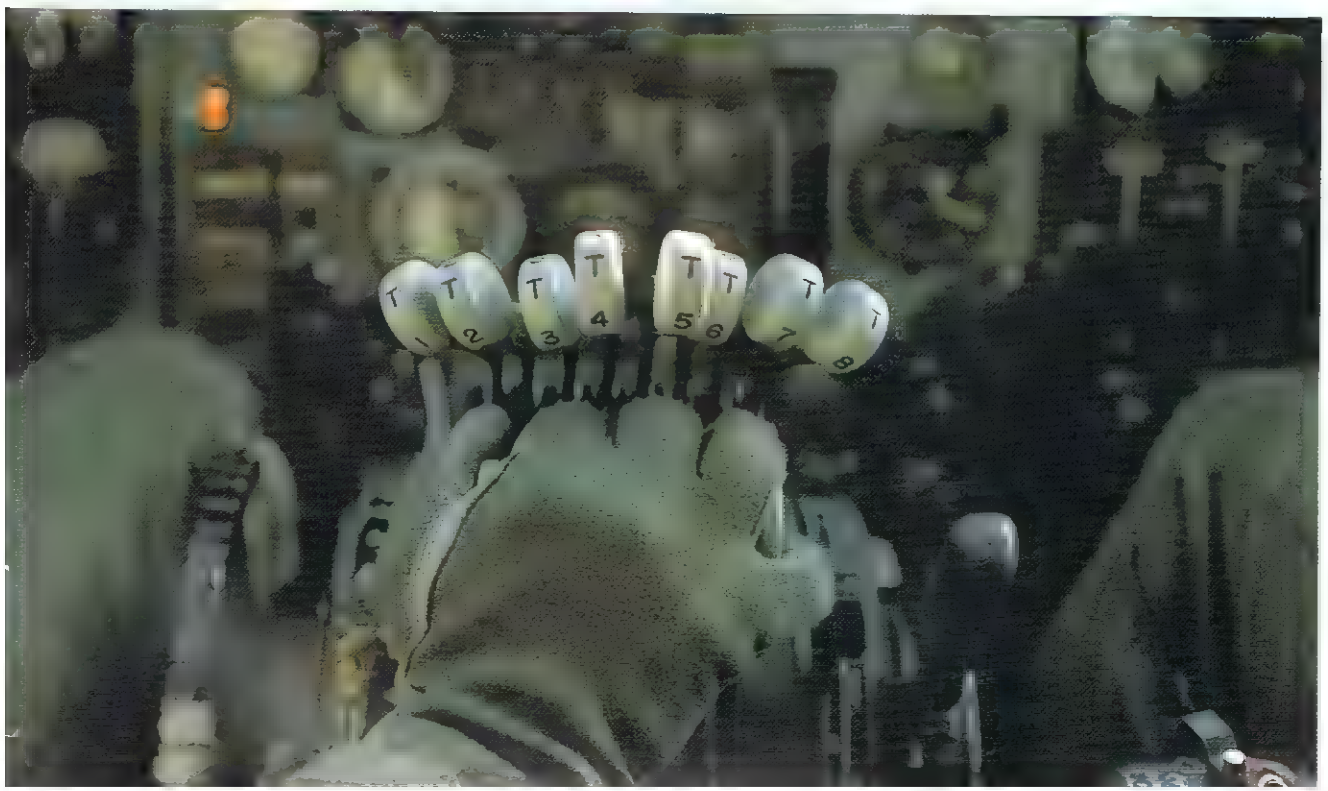
happen is that you can put out the fire in the engine. If you put out two engines in the outboards you not only lose the engines but you give yourself a nightmare of a directional control problem. It's a problem that is serious. It gets your attention."

For this and other reasons, the B-52G has a future limited to about 1995 – whether or not Draconian budget cuts endanger SAC plans for a future force based on the B-2. In fact, the first G model has been retired from service and is now a memorial in front of Building 500 at SAC HQ, Offutt AFB.

Of the 157 B-52Gs flying, 98 were converted to carry ALCM (AGM-86B) missiles, though none is scheduled for the ACM (AGM-129) advanced missile. For arms control treaty purposes, ALCM-equipped B-52Gs have a modification at the wing root, a curved fairing that replaces the otherwise sharp angle between fuselage and wing sweep. This enables Soviet reconnaissance satellites to distinguish nuclear from conventional B-52s.

Some G and H model B-52s have the Strategic Radar modification – Strat Radar, for short – software that gives the radar navigator more user-friendly instruments and to ease

Training for SAC's tan and bomber fleets is undertaken by the 93rd Bomb Wing at Castle A California, where B-52 KC-135s perform endle circuits of the traffic pattern. Some of the aircraft still wear the o style camouflage with characteristic white undersides and wavy pattern along the fusel



A fistful of throttles! Th B-52's cockpit is not unnaturally dominated huge bank of engine controls and instrumen between the pilots, eve individual reading or le magnified eight-fold. E pilot is provided with b flight instruments, and head-down display console for the EVS/ter avoidance radar.

Rockwell B-1B
96th Bombardment Wing
Dyess AFB, Texas

Until the Northrop B-2 enters service, the Rockwell B-1B is Strategic Air Command's premier bomber, tasked with the all-important penetration mission. At present it is armed with only SRAMs and free-fall weapons, but does have the ability to carry AGM-86B and AGM-129 air-launched cruise missiles, as shown here. This stand-off, missile-launching role will become increasingly important to the B-1 fleet as B-2s adopt the penetration role. After a long and troubled gestation, the B-1 is emerging as the world's most effective strategic bomber, capable of penetrating current defences by using a combination of low-level performance, electronic countermeasures (although these have provided more than their fair share of development difficulties) and a carefully-designed shape to reduce radar reflectivity to the minimum without employing dedicated low-observables technology. One hundred B-1Bs were built, of which three have been lo assigned to the Air Force Flight Test Center (6512th Te Edwards AFB, California, for permanent test work, the being operated by SAC with six squadrons. The units wings, the 28th (Ellsworth AFB, South Dakota) and 96 Bomb Wings having two squadrons each, while the 31 North Dakota) and 384th (McConnell AFB, Kansas) Bor one squadron each. One of the Dyess units is assigned to the sophisticated bomber.

Defensive Avionics System

Although it has a low radar cross-section, the B-1B is heavily reliant on electronic countermeasures to protect it during low level penetration. The principal system is the AN/ALQ-161 integrated warning/countermeasures system. Altogether 107 separate items make up the system, these housed in the tailcone, fin-tip, wing roots and avionics bays. ALQ-161 is basically automatic, detecting hostile emissions through receivers placed strategically around the aircraft, analysing and prioritising them before instructing jammers to obliterate or confuse them. The DSO monitors the system on two graphic displays, showing threats with alpha-numeric labels. Another display gives tabulated information on threats. At any time the DSO can override the ALQ-161 and command jamming if he deems it appropriate.

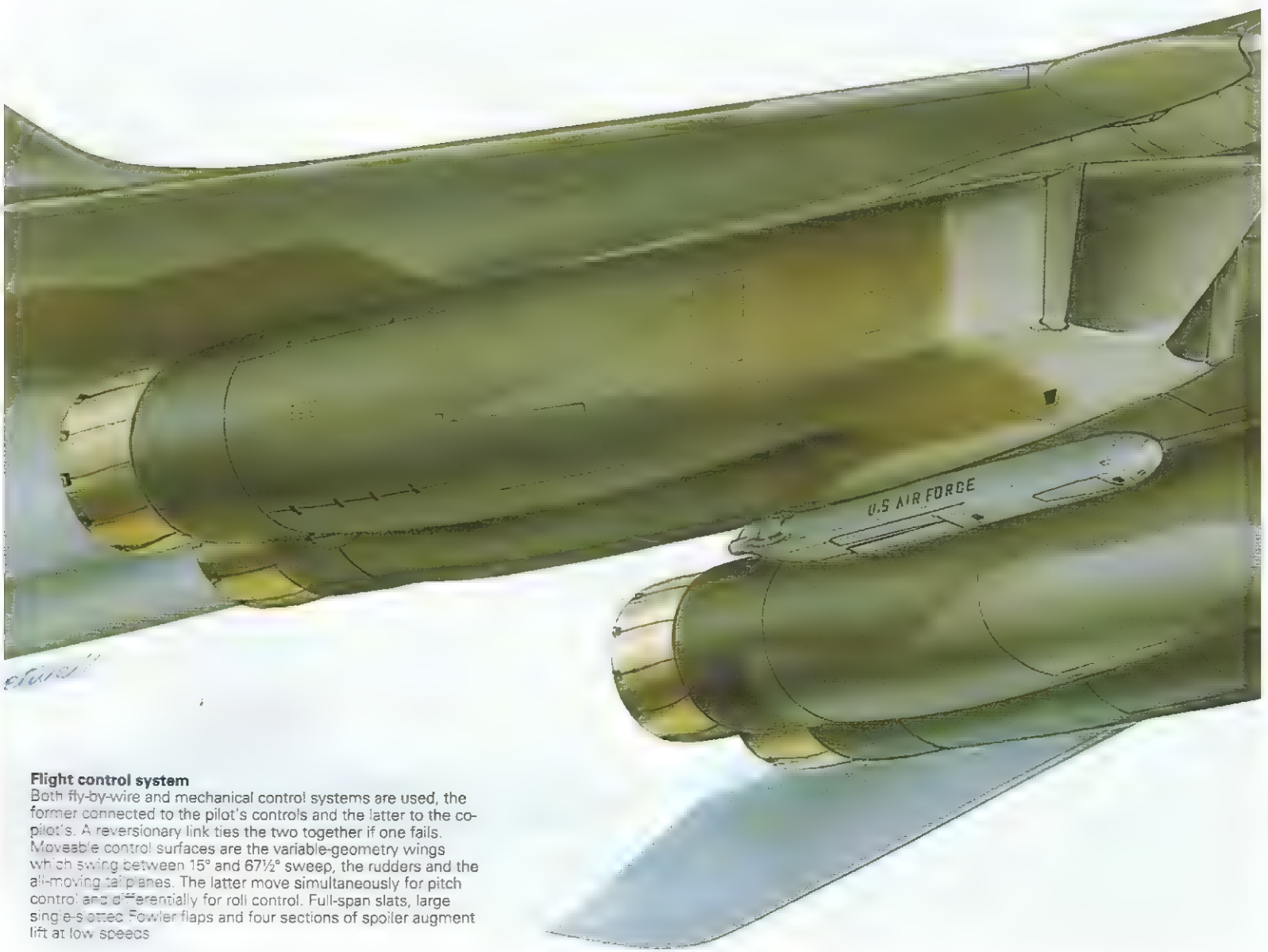
Development history

What finally became the B-1B began as a study project in 1961 for a Subsonic Low Altitude Bomber (SLAB), initiated in the wake of the shoot-down of Francis Gary Powers' U-2 and the subsequent cancellation of the XB-70 high-altitude bomber programme. It was deemed at the time that the only effective way to counter SAMs was to penetrate at low level. Throughout the 1960s a series of new studies (and acronyms) was undertaken, culminating in the AMSA (Advanced Manned Strategic Aircraft). By 1969, a contract was awarded to Rockwell, and AMSA became the B-1. The prototype B-1A was rolled out at Palmdale on 26 October 1974, and finally flew on 23 December that year. By June 1976, three B-1As were flying, this version possessing Mach 2 performance at high altitude, but subsonic at low altitude. However, the programme had become increasingly expensive, and at all times had been dogged by technical difficulties. On 30 June 1977, President Jimmy Carter announced that no B-1A production would be authorised, largely on the grounds that cruise-missiles launched from stand-off ranges could perform an adequate penetration task. Testing was allowed to continue, however, resulting in yet more acronyms, the last of which was LRCA (Long Range Combat Aircraft). On 2 October 1981, President Reagan announced that the LRCA would go into production as the B-1B, with considerable improvements for the low level role, it being deemed that the US now needed a long range strategic aircraft to partially rep ace the ageing and vulnerable B-52. On 18 October 1984, the first production B-1B flew from Palmdale, from an eventual order of 100.

Structure
The heart of the B-1B's structure is the massive titanium wing carry-through box that lies across the centre of the fuselage. At each end is a hinge fitting for the swing-wing, which is attached by a giant pin. This pin is so tight-fitting that it has to be soaked in liquid nitrogen to shrink it before fitting. The WCT also supports the main undercarriage. Immediately forward and aft of the WCT are intermediate fuselage sections, to which are attached the rear fuselage and empennage, and the crew compartment/nose section. The wing/body blending is important, for it strengthens the structure with a large saving in weight, as well as providing additional volume for internal carriage. A key component of the tail section is a forged steel box which supports the fin and is spindle for the all-moving tailplanes. Much use is made of radar-absorbent material in key areas.

Mission profile
Currently the B-1B is employed on penetration missions only, and consequently is armed with free-fall nuclear weapons and SRAMs. A typical mission would involve a mix of weapons. After a high level cruise to the theatre of operations, the B-1B would launch SRAMs against defences along the border, continuing with the penetration at low level. The gravity bombs would be used against the primary targets, dropped from low level and retarded by parachute to allow the bomber to escape damage from the explosions. When B-2s adopt this penetration role, B-1s will increasingly become stand-off weapons, using cruise missiles in particular. Maritime weapons are another likely possibility for the B-1B force in the future.

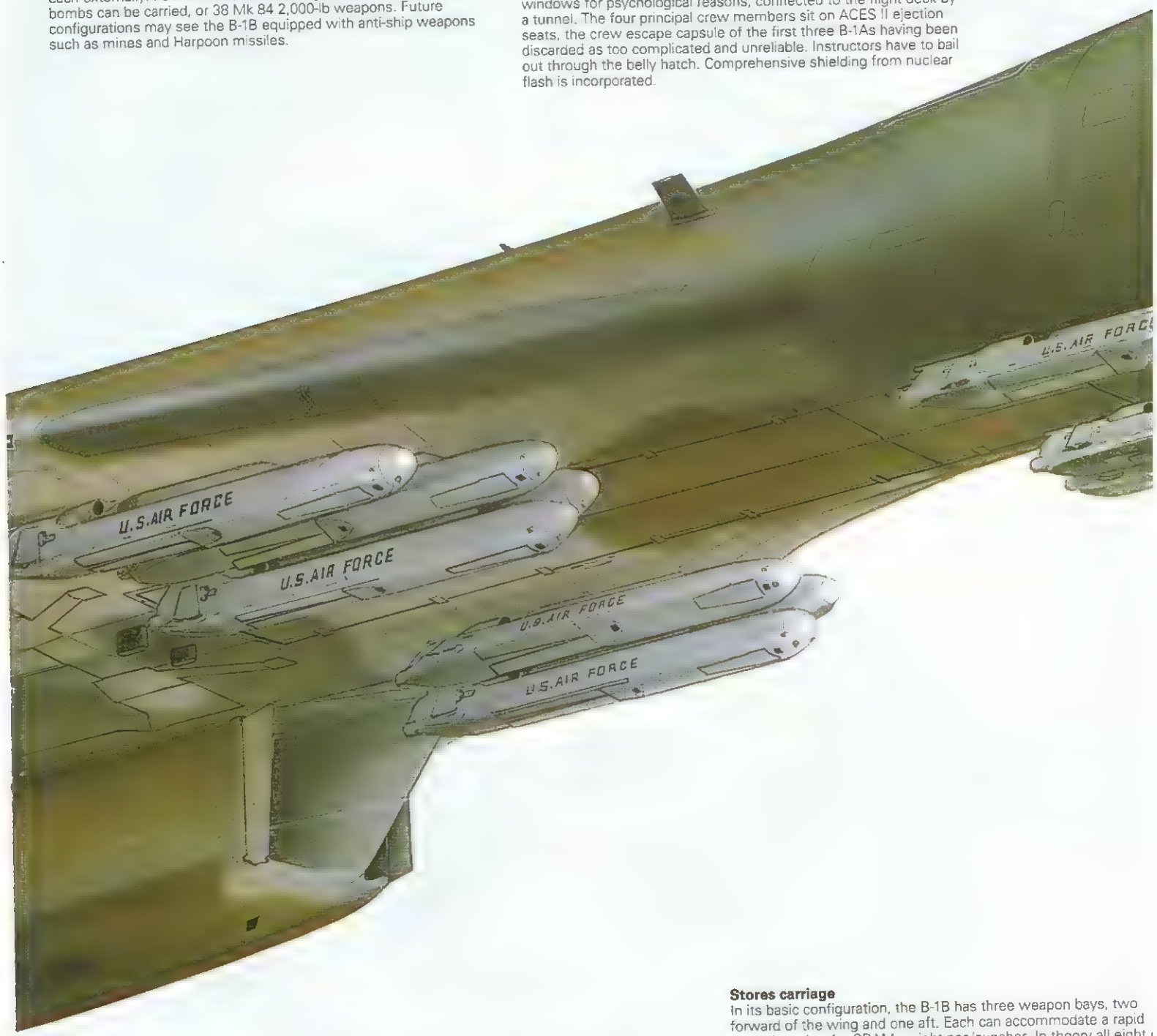
Fuel
Fuel takes up much of the B-1B's internal volume, tanks being located in the WCT box, wing structure, rear fuselage and upper forward fuselage. Total capacity is thought to be in the region of 93 tons. Additional fuel can be carried in the weapons bays when required. Centre of gravity is maintained by the Fuel and Center of Gravity Management Subsystem (FCGMS), which pumps fuel between tanks to keep the aircraft balanced. Nitrogen is pumped into the tanks as fuel is used to maintain pressure.



Flight control system
Both fly-by-wire and mechanical control systems are used, the former connected to the pilot's controls and the latter to the co-pilot's. A reversionary link ties the two together if one fails. Moveable control surfaces are the variable-geometry wings which swing between 15° and 67½° sweep, the rudders and the all-moving tailplanes. The latter move simultaneously for pitch control and differentially for roll control. Full-span slats, large single-slotted Fowler flaps and four sections of spoiler augment lift at low speeds

Weapon load
The B-1B can carry a huge variety of weapons, ranging from the AGM-86B cruise missile to the humble iron bomb. The B83 is the primary nuclear free-fall weapon used, with the B28, B43 and B61 viable alternatives, although the B28 and B43 are getting old. Twenty-four B83s can be carried internally, with another 14 externally. A similar number of B61s can be carried. In the missile-launching role, either 24 SRAMs or eight ALCMs can be carried internally, with 14 of each externally. For conventional bombing up to 128 Mk 82 500-lb bombs can be carried, or 38 Mk 84 2,000-lb weapons. Future configurations may see the B-1B equipped with anti-ship weapons such as mines and Harpoon missiles.

Accommodation
Crew entry is via a hatch behind the nosewheel, with an integral ladder. On the main flight deck sit the pilot and co-pilot, with optional instructor's seats. The windscreens offer superb visibility, and are gold-tinted to reduce radar reflectivity by conducting radar energy through to the blended structure. Both pilots are provided with fighter-style control columns and left-handed thrust lever quadrants. In the rear sit the Defensive Systems Officer (DSO – port) and Offensive Systems Officer (OSO – starboard), with small windows for psychological reasons, connected to the flight deck by a tunnel. The four principal crew members sit on ACES II ejection seats, the crew escape capsule of the first three B-1As having been discarded as too complicated and unreliable. Instructors have to bail out through the belly hatch. Comprehensive shielding from nuclear flash is incorporated.



Powerplant
Power for the B-1B comes from four General Electric F101-GE-102 turbofans, mounted in pairs beneath the wing glove structure. Each engine has a bypass ratio of 2 and provides 75.6 kN (17,000 lb) thrust in military power, and 133.4 kN (30,000 lb) with augmentation. The afterburner has 28 chutes carrying hot core air and a further 28 carrying cold bypass air. Where the two are mixed are the flameholders for augmentation, which ■ electronically-controlled. Quick-start capability is vital in a strategic bomber, and each engine nacelle contains an APU with a power shaft to each engine. Alternatively an engine can be started using low pressure compressor air from the other in the nacelle. As the crew arrives at the aircraft, they punch a switch on the nosewheel which starts the APUs. By the time they reach their stations the APUs are running and all four engines can be started simultaneously. The intakes have ■ serpentine trunk leading to the engine to shield the compressor blades from radar energy, and a moveable intake lip controls the flow into the inlet. The variable ramp of the B-1A has been deleted, resulting in a reduction of maximum high altitude speed from Mach 2.2 to Mach 1.25, although low level speed is slightly increased.

Stores carriage
In its basic configuration, the B-1B has three weapon bays, two forward of the wing and one aft. Each can accommodate a rapid rotary launcher for SRAMs, eight per launcher. In theory all eight c be launched within 45 seconds from each launcher. Conventional weapons can be carried in vertical stacks. Fuel tanks can be fitted any of the weapon bays to increase range. In the cruise-missile launching role, the two forward bays are altered by a moveable bulkhead to create a small bay for ■ fuel tank and a long bay to accommodate a rotary launcher and eight AGM-86B or AGM-129 cruise missiles. Fourteen more missiles can be carried on eight external pylons. On each side one pylon is mounted under the forward fuselage, two side-by-side under the wing glove and one under the fuselage alongside the engine nacelle. The forward pyl can take two missiles, while the inboard wing glove pylon can tal three. SRAMs and bombs can similarly be carried externally, alth it must be remembered that external weapons carriage has a considerable adverse effect on radar cross-section.

Offensive Avionics System
At the heart of the OAS is the APQ-164 phased-array radar. The antenna is fixed and canted down to avoid giving a large radar return, all sweeping functions being handled electronically. Altogether 13 radar modes are available, including ground mapping, terrain following and avoidance, weather, moving target indication and tanker rendezvous. Synthetic Aperture Radar (SAR) technology is incorporated for high resolution mapping of targets, also allowing en route updates of the INS (Inertial Navigation System). The OSO has three large CRTs in front of him, one of which displays the radar picture. Like the DSO, he has a hand controller for rapidly moving cursors and calling up additional information.

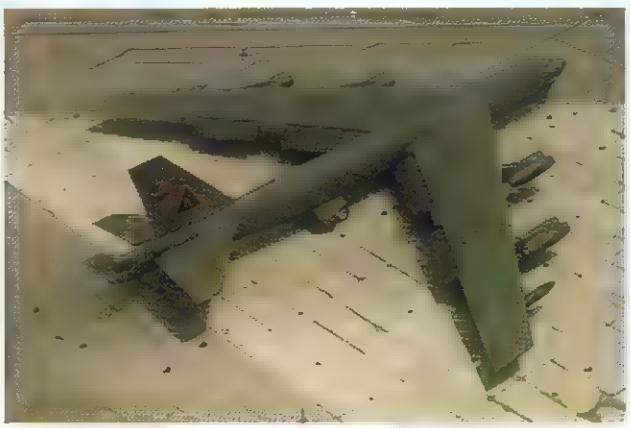
SMCS
Originally known as the LARC (Low Altitude Ride Control), the SMCS (Structural Mode Control System) is an innovative feature to reduce the effects of turbulence on the airframe at low level and high speed. Automatically-controlled, the SMCS utilises two small anhedralled vanes on the aircraft's nose and the bottom section of the three-piece rudder to damp out the effects of turbulence, and so reduce the aero-elastic whipping effect on the long fuselage. Accelerometers detect turbulence, and the SMCS computer then instructs the vanes and rudder to counteract any gust effects. The vanes can move up or down through 20°, and react very quickly, demonstrating rotational speeds of 200° per second.

ise missile
ered by the Williams International F107-WR-101 turbofan of
ie 272-kg (600-lb) thrust, the Boeing AGM-86B Air-Launched
se Missile (ALCM) is the principal stand-off weapon
loyed by Strategic Air Command, at present carried only by
Boeing B-52 although in short-term prospect for the B-1B.
launch aircraft's OAS provides initial position alignment prior
unch, and the missile flies a low level, high subsonic speed
ile to its target, using TERCOM (terrain contour matching)
NS update, giving phenomenal accuracy over ranges up to
) km (1,555 miles). A 200 kT yield nuclear warhead is fitted.
already low radar cross-section of the AGM-86B will be
ner reduced on the General Dynamics AGM-129 Advanced
se Missile shortly to enter service.

Undercarriage
The strong main undercarriage supports about 90 per cent of the weight of the B-1B on the ground. The legs are forged from high-grade steel and weigh 1360 kg (3,000 lb) each. The smaller nosewheel unit can turn through 76° right or left for steering, and can swing free through 360° for manoeuvring by vehicles. Five rotor carbon brakes are fitted, made by Goodyear (as are the tyres). No reverse thrust or brake parachute is fitted. The gear is retracted by electronically-controlled hydraulic actuators, and takes 12 seconds to complete extension or retraction.

Above: In the maritime role, the B-52G can carry AGM-84 Harpoon anti-ship missiles. Against high-value targets, these would be launched in a salvo to saturate the ship's defences and provide a high chance of scoring several crippling blows.

Right: In order to allow ratification by the Soviet Union, the B-52G aircraft configured for cruise-missile carriage have had a distinctive curved fairing added to the wing-roots, displayed here by an aircraft of the 379th Bomb Wing. These fairings distinguish the aircraft from non-cruise carriers on satellite-gathered imagery without affecting the aircraft's performance or handling.



the job of using radar to navigate and bomb. This modification is based on a TCTO (time compliance tech order) and will in due course appear throughout the B-52 fleet.

Some of these aircraft have been equipped for external conventional weapons. These use pylons originally intended for the long-defunct Hound Dog missile and MERs (multiple ejector racks), making it possible to carry 12 750-lb (340-kg) bombs on each wing, in addition to 27 in the bay, giving a total of 51. Most (but not all) of the remaining ALCM-equipped G models without Strategic Radar have a conventional capability only internally, for 27 750-lb bombs carried in the bay.

Conventional weapons

Non-ALCM B-52G models, of which there were 68 at one time including the aircraft now on display at Offutt and non-SAC machines, all possess the full internal/external conventional capability. This group of airplanes can use Hound Dog pylons with MERs or stub pylons. The stub pylons, in turn, are adaptable with both MERs and the Heavy Stores Adapter Beam (HSAB). HSABs are used for heavy-class conventional weapons such as the Mk 84 2,000-lb (907-kg) bomb (for which there are nine stations) or the AGM-84A Harpoon anti-shipping missile. SAC has 30 'kits' enabling aircraft to be configured for Harpoon, meaning a maximum of 30 B-52Gs will have that capability at a time. The Harpoon is in use with one of its three units assigned the conventional bombing mission, located at Loring (and recently with the deactivated 60th BS on Guam).

The conventional bombing role, discontinued after the Vietnam War in 1973, was assigned to some B-52Gs again beginning in May 1988. This includes maritime operations, including use of the Harpoon.

The B-52H model with TF33 turbofans is not scheduled to be removed from service any time before 2001, and possibly not even then. The B-52H is the primary cruise missile launcher for the SAC force; by mid-1990 every H model in the fleet was to be equipped for ALCM (AGM-86) or ACM (AGM-129) – though the latter missile is still some time away from entering service.

Conversion to ALCM or ACM capability on the B-52H is distinguished externally by a redundant or extra 'elephant ear' ALT-32 antenna, which protrudes at a 90-degree angle from the fuselage side, just above the original aerial canted at 45 degrees down: the purpose of the second instrument is solely to identify the aircraft as a nuclear carrier to observing satellites.

Although not routinely assigned a conventional bombing mission, all B-52Hs also have the '728 mod' (from a manual TO 1B-52H-728), another TCTO update item, which enables them to carry external conventional weapons. This makes use of the old Hound Dog pylons with adapter beam and double MERs.

The ALCM, designated AGM-86B, is today's hi-tech stand-off weapon and will soon be joined by the ACM, designated AGM-129. The B-52G/H can carry up to eight SRAM on a rotary launcher that resembles the cylinder of a revolver.

The B-52's six-man crew (both G and H models) consists of pilot (or AC, aircraft commander), co-pilot, electronic warfare officer (EWO), navigator, radar navigator (RN) and fire control operator (FCO), the last-named being the gunner, who sits up front and operates the tail gun by remote control.

About 20 IPs (instructor pilots), SAC-wide, are checked out in both B-52G and B-52H models. One of them, Major Brian (Buck) Rogers, confessed that he is partial to the H model. "The engines are better. The H model has a more commonsense approach to the layout of racks in the cockpit. You have things positioned differently to allow space for a bunk and an oven – not just a microwave but an actual thermal heating oven. You *can* put an oven in a G model but not easily; some bases do, some don't.

"The fuel consumption at cruise for a G model is much higher than for the H model because turbojets are less efficient than fans. Range of the H is considerably more, by as much as 20 per cent, although speed is the same for most models since speed is determined by airframe. Refuelling the H model is easier because it is more responsive – the response to the pilot's controls is quicker, whereas if you make a mistake in the G model at heavy weight, you're off the boom before you know it.

"The extra power of the H enables you to lose an engine. Say, you get a heat-seeking missile which will blow a pod clean off, or damage two engines in a pod. In the H model you can lose them, it's no problem, you have plenty of reserve power; but in the G model it becomes more critical.

"In the G model you have idiot lights staggered all over the

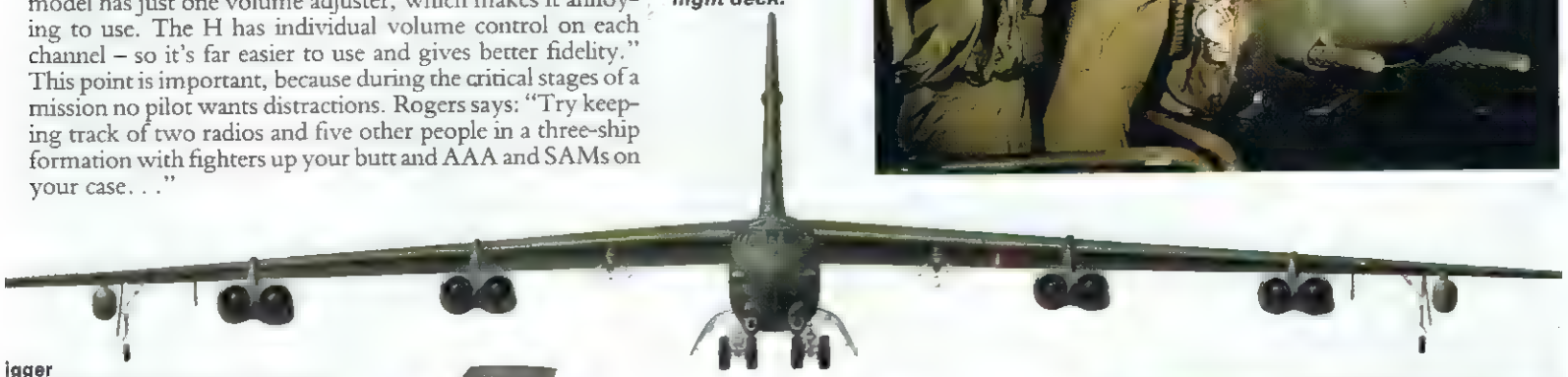
Boeing B-52G

One hundred and ninety three Boeing B-52Gs were built, the first entering service on 13 February 1959 with the 5th Bomb Wing. The aircraft have been considerably altered since those days, equipped with systems to maintain them as viable weapon platforms for service into the 1990s. At present the force is split between cruise-missile carrying, maritime operations and conventional free-fall bombing, but the aircraft has begun the retirement process, one which will be accelerated as the delivery of B-2s causes a knock-down effect on the SAC bomber force. Illustrated here is an aircraft of the 42nd Bomb Wing at Loring AFB, Maine, a maritime-dedicated unit

cockpit. The H model has a central caution panel centred at the pilot's right kneecap. Everything is nicely grouped in this one place.

"The difference in the interphone systems between the G and H models is like night and day. The G model has a Tweet (Cessna T-37) interphone and the H has a T-38 phone. The G model has just one volume adjuster, which makes it annoying to use. The H has individual volume control on each channel – so it's far easier to use and gives better fidelity." This point is important, because during the critical stages of a mission no pilot wants distractions. Rogers says: "Try keeping track of two radios and five other people in a three-ship formation with fighters up your butt and AAA and SAMs on your case. . ."

Right: The B-52G has a tail armament of four 0.50-in machine-guns, remotely sighted by the gunner sitting on the main flight deck.



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nain undercarriage supports the main
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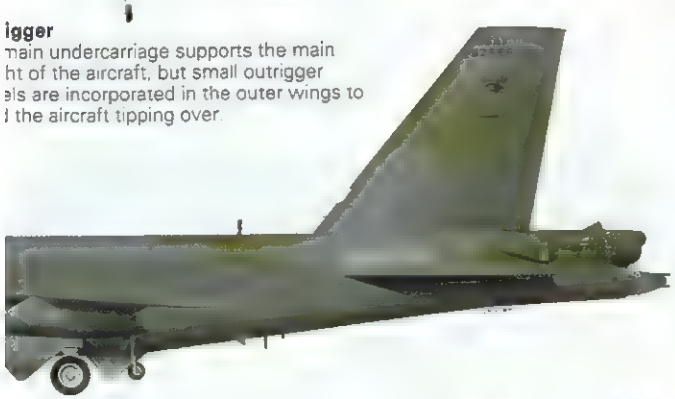
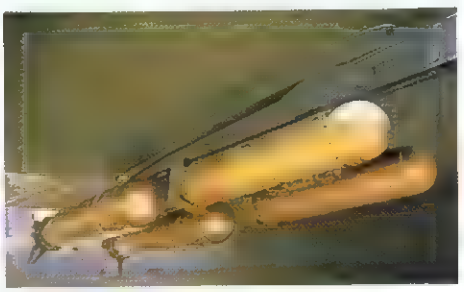
the aircraft tipping over.



n undercarriage
B-52 is supported on four main
ercarriage units, arranged in two pairs
ndem. Each strut has two wheels. The
s swivel to allow crabbing during
swind take-offs and landings.

Wing roots
B-52Gs assigned to conventional roles such as free-fall bombing or maritime operations have unaltered wing roots, with a sharp-angled wing/fuselage join. Those assigned to nuclear (cruise-carrying) roles have a strakelet added to round off the join so they can be distinguished by reconnaissance satellites.



One unit which had a maritime commitment (now deactivated) was the 320th Bomb Wing at Mather AFB, California. This aircraft shows the carriage of conventional maritime mines on the wing pylon.

Bomb bay
The large bomb bay runs from forward of the rear undercarriage to under the wing. In the nuclear role it can accommodate up to eight B28 or B43 free-fall weapons, or 12 B61 or B83 bombs.

Powerplant
B-52Gs are powered by eight Pratt & Whitney J57-P-43WB turbojets, distinguished by a constant profile nacelle. These develop 6237 kg (13,750 lb) of thrust for take-off with water-methanol injection.

ritime operations
ne B-52Gs have a maritime
nmitment, utilising the aircraft's
eptional range and load-carrying
lity. This aircraft is fitted with the
ximum load of 12 AGM-84
poon anti-ship missiles,
ough 10 is a more usual load.
nes are another maritime store
ularly carried.

Gun radar
Above the gun turret is the radome for the ASG-15 fire control radar. Control is effected by a dedicated gunner in the crew compartment.

Tail gun
In common with all previous B-52s, the G-model has a quartet of 12.7-mm (0.50-in) M3 machine-guns in the tail, although it was the first model to dispense with a tail gunner position.

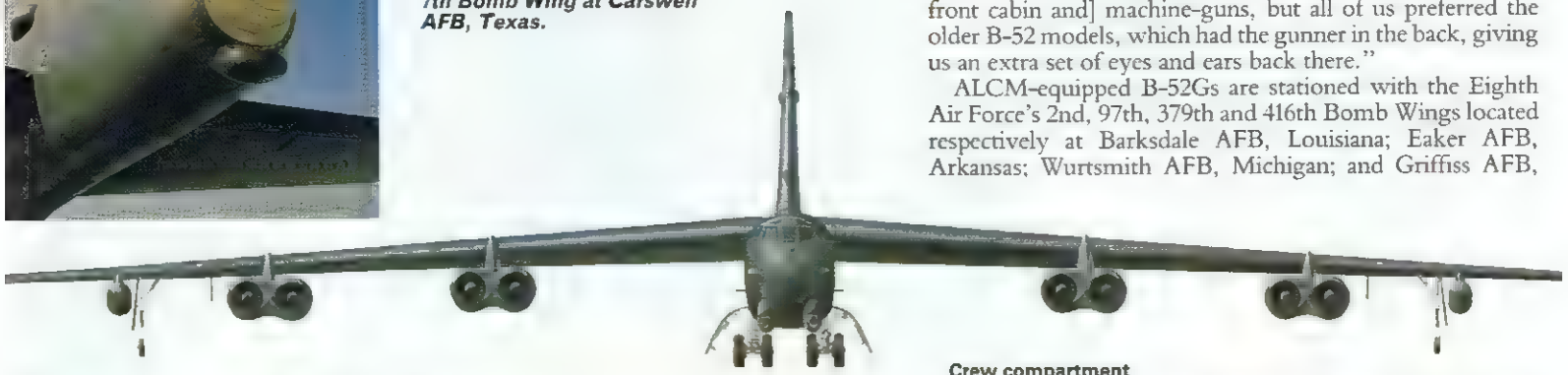
Wing
The mighty wing is built around a strong two-spar box, with a hefty carry-through structure in the top of the fuselage. Virtually the entire area between the spars is given over to fuel carriage. The wing is exceptionally flexible to absorb differing loads and turbulence.

Any enemy fighter getting behind the B-52H is in for a nasty surprise, courtesy of the 20-mm six-barrel rotary cannon, aimed with the aid of the radar mounted above it. The aircraft here is from the 7th Bomb Wing at Carswell AFB, Texas.

The B-52G was armed with four .50-cal. Browning machine-guns, while the H model has one 20-mm M61A1 Gatling gun cannon. B-52 pilot Lieutenant-Colonel Larry Nilssen says, "The machine-gun puts a lot out there. If you're an adversary, it's like flying into a bucket of marbles.

"Gunners seem to prefer the G model with [gunner in the front cabin and] machine-guns, but all of us preferred the older B-52 models, which had the gunner in the back, giving us an extra set of eyes and ears back there."

ALCM-equipped B-52Gs are stationed with the Eighth Air Force's 2nd, 97th, 379th and 416th Bomb Wings located respectively at Barksdale AFB, Louisiana; Eaker AFB, Arkansas; Wurtsmith AFB, Michigan; and Griffiss AFB,



Boeing B-52H

Universally known through SAC as the 'Cadillac', the B-52H has significant upgrades compared to the 'G' which make it a much more capable aircraft, especially in terms of load/range performance, and in crew comfort. One hundred and two were originally built, the last delivered to the Air Force in October 1962, ending B-52 production. Like the G-model, the 'H' has been the subject of many improvement programmes, including the constant reappraisal of its electronic countermeasures equipment. This example is seen wearing the marks of the 7th Bomb Wing at Carswell AFB, Texas

Crew compartment
The B-52 is flown by six crew, arranged on two decks. On the upper deck sit the two pilots, while behind them sit the Electronic Warfare Officer (starboard) and gunner (port), facing backwards. On the lower deck sit the navigator and radar navigator/bombardier, facing forwards

Powerplant
Giving the B-52H its exceptional range/load performance is the Pratt & Whitney TF33-P-3 turbofan, which produces 7711-kg (17,000-lb) thrust for take-off. The extra power is more than useful with heavyweight take-offs, and the low fuel burn gives a maximum range of around 16090 km (10,000 miles). Cabin noise is considerably reduced, with a consequent beneficial effect on crew fatigue.

Radar
In the nose is the Norden APQ-156 multi-mode radar, the principal role for which is targetting. The radar embodies synthetic-aperture technology. Terrain-avoidance radar is also incorporated to give pilots steering commands on their head-down displays.

Fuel
The enormous internal fuel tanks are augmented by fixed 2650-litre (700 US-gal) external tanks, raising total capacity to 181813 litres (48,030 US gal).

Water
Water-methanol mixture for the engine boost is housed in a 4542-litre (1,200-US gal) saddle tank behind the crew compartment. The liquid is ducted along the leading edge structure to the engines.

EVS
At the heart of the B-52's ability to fly and fight at low level i all weathers is the Electro-Optical Viewing System, the sensors for which are located in two large blisters under the nose. The FLIR and LLLTV provide an image of what's ahea of the bomber on screens displayed at pilot and navigator stations. Together with the terrain-avoidance radar, these allow the B-52 crew to navigate, identify targets and launch weapons at low level while having no outside visibility (eithe due to night operations, bad weather or nuclear shielding).

ECM
The B-52 is comprehensively protected against hostile radars. Equipment includes an ALT-28 jammer on top of the nose, ALQ-117 deception jammers facing sideways from the nose, ALQ-172 deception jammer forward of the gun-control radar and farms of aerials for the ALQ-155 system clustered under forward and rear fuselage. Radar warning receivers and warning radars are mounted in the extreme tail and under blisters on the vertical fin. Associated equipment bays have ram air for cooling. All ECM equipment is controlled by the Electronic Warfare Officer in the rear of the crew compartment.

Camouflage
Since the early years of the Vietnam war, the B-52 force flew with a three-tone tactical scheme with light undersides. This is the latest scheme, an all-over dark grey

New York. Non ALCM-equipped B-52Gs are assigned to Eighth Air Force's 2nd (again) and 42nd Bomb Wings at Barksdale and Loring AFB, Maine and to Fifteenth Air Force's 93rd at Castle AFB, California. B-52H models are assigned to Eighth's 7th and 410th Bomb Wings at Carswell AFB, Texas, and K. I. Sawyer AFB, Michigan, and to Fifteenth's 5th and 92nd Bomb Wings at Minot AFB, North Dakota, and Fairchild AFB, Washington.

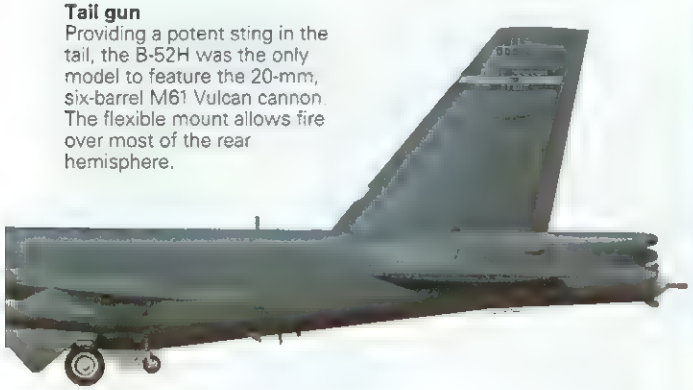
Conventional duties

After having no B-52 units with conventional missions since 1973, in May 1988 SAC announced that exclusively conventional duties would be assigned to four B-52 units. Since then, one of these (the 320th Bomb Wing at Mather AFB, California) has been deactivated and a second (at Andersen AFB, Guam) followed suit. This leaves the 42nd Bomb Wing at Loring AFB, Maine, plus one squadron of the 2nd Bomb Wing at Barksdale AFB, Louisiana, which are assigned solely conventional bombing duties.

In January 1990, plans were announced to deactivate the only overseas B-52 outfit, the B-52G-equipped 43rd Bomb Wing's 60th Bombardment Squadron at Andersen, this being completed at the end of April 1990. Other changes in the B-52 force are planned in the near term. In fiscal 1991, each of several units is giving up B-52H aeroplanes to enable the Griffiss-based 416th Wing to convert from B-52G to B-52H. The wing's 668th Bomb Squadron will convert from 10 B-52Gs to 13 B-52Hs. During 1991, B-52H airframes will be given up by the bomb wings at Fairchild (three), Minot (three), Carswell (four), and K. I. Sawyer (three). In

On take-off, B-52s immediately adopt a nose-down attitude. With TF33 turbofans fitted, the B-52H is mo powerful, makes less noise and creates less smoke than the B-52G Note the raised spoile which provides roll control at low speeds and air braking.

Tail gun
Providing a potent sting in the tail, the B-52H was the only model to feature the 20-mm, six-barrel M61 Vulcan cannon. The flexible mount allows fire over most of the rear hemisphere.



The 'Seattle Seahawk' badge identifies these B-52Hs as belonging to the 92nd Bomb Wing at Fairchild AFB, Washington. All H-models are configured to carry AGM-86B cruise missiles, but their wing-roots do not need the extra identification fairing as the different planform of their engines provides sufficient distinction.

Above: Although cuts have made inroads into the fleet, the B-52 is still SAC's most numerous bomber, and still capable of a wide variety of missions. While the B-52G is slowly being retired, the H-model will continue in the stand-off role into the next century. These H-models are from the 7th Bomb Wing at Carswell.

Right: A 416th BW B-52G out of Griffiss AFB positions itself for refuelling. Clasped under its wings are a dozen AGM-86B cruise missiles. Readily visible (as indeed they are meant to be) are the wing root strakelets fitted to cruise-carrying 'Gs'.

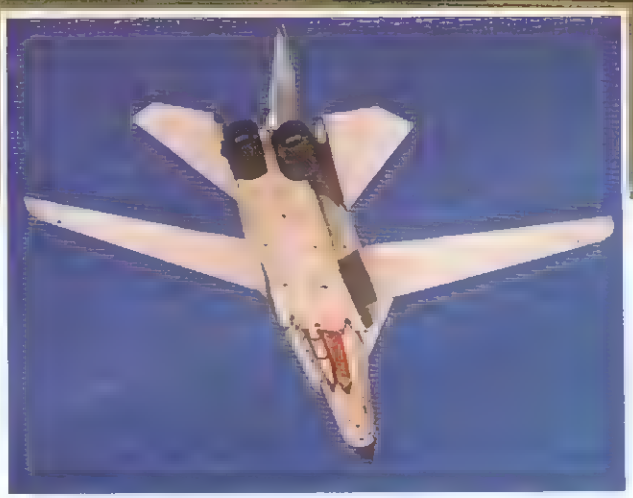
addition, the wing at Wurtsmith is scheduled to give up 6 B-52Gs, apparently to be retired.

The General Dynamics FB-111A still equipped two SAC bomb wings (48 airframes) going into the 1990s and, although these aircraft were scheduled to revert to tactical forces by 1992 their departure would be lamented by men who fly the aircraft and are fond of it. Lieutenant-Colonel John Plantikow of the 380th Bomb Wing, Plattsburgh AFB, New York, is the high-hour FB-111A pilot with more than 2,400 flight hours. The other wing, the 509th at Pease AFB, New Hampshire, was going out of the FB-111A business in spring 1990 (the unit that bombed Hiroshima was converting from FB-111A to an air-refuelling mission) and the 380th was to end its role as the final FB-111A outfit in 1992.

Powered by two Pratt & Whitney TF30-P-107 turbofan engines, and making use of variable geometry wing planform also found on the B-1B, the FB-111A is a 'kissing cousin' of the F-111A/D/E/F Aardvark strike aircraft serving in the tactical forces (and well known for their role in April 1986 operations against terrorist-related targets in Libya). The FB-111A has the larger wing (70 ft span, unswept) associated with the Australian F-111C and the unbuilt F-111K for the Royal Air Force. The FB-111A also has heavier, sturdier landing gear than tactical F-111s.

Plantikow says: "I've flown it at 200 feet [altitude] in the mountains at night at supersonic airspeeds. Its penetration capability is spectacular. But since we're the bastard child of SAC, we haven't had the upgrades to our aircraft that would keep it up to the state of the art."

The FB-111A is flown by an aircraft commander (AC) in



the traditional location in the left seat and a radar navigator (RN) in the right. For the nuclear mission, these men have their vision protected by plizit in the form of a Darth Vader-style faceplate. The men sit in a McDonnell Douglas ejection module designed for flying in a shirtsleeve environment.

Says Plantikow: "We wear a coverall-type flight suit. We don't need a G-suit for the SAC mission. The escape capsule has a survival kit so there's no need to carry parkas or parachutes. The thing will float. In fact, a pin on an attachment to the pilot's stick turns the stick into a bilge pump."

In the 1980s, the entire FB-111A fleet was modified with a stall inhibitor system (SIS), which corrects earlier control problems and makes the aircraft easier to handle.

Stand-off missile

The FB-111A can accommodate B28/B61 nuclear bombs and would employ these against principal targets. Key to the FB-111A's offensive role, however, is the AGM-69 SRAM (Short-Range Attack Missile), a 190-in (4.83-m) semi-stand-off missile married to the W69 nuclear warhead and credited with a range of 100 miles (161 km). While the FB-111A must penetrate air defences and approach its target, SRAM enables this big-winged Aardvark to launch without actually overflying the objective.

The radar navigator selects each missile in turn, looks at the updating of his KT-76 inertial guidance, and launches the SRAM. The missile's rocket motor pushes it to about Mach 3.0. Nearing the target, a second propulsion stage kicks in. This increases speed to Mach 5.0 and makes it virtually impossible to defend against. SRAM also has an exceedingly low radar cross-section.

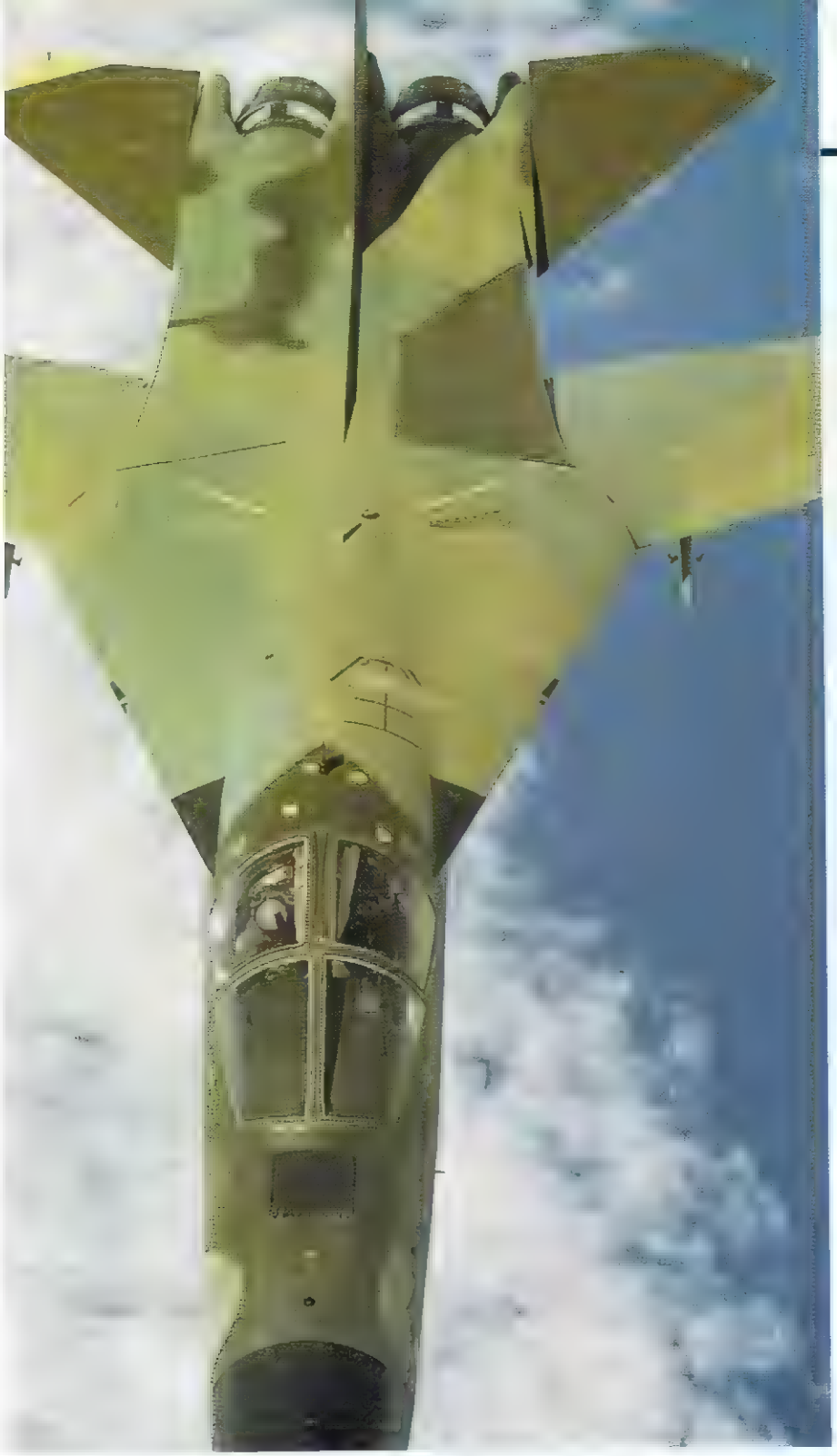
B-52 pilot Larry Nilssen says: "I liken the SRAM to Fuzzy Thurston, the pulling guard for the Green Bay Packers. He runs interference for the ball carrier. He takes out anyone who's going to stop the ball from getting there." Though SRAM can be, and is, employed against primary targets, it can also be used to push defences out of the way. The FB-111A can be used mainly for this purpose.

The departing SAC FB-111As are to be redesignated F-111G and given a tactical mission (though retaining SRAM capability). Eighteen of these aircraft were to go to Cannon AFB, New Mexico, by mid-1991, followed by 30 more in late 1991.

The approaching end of the FB-111A's career in SAC marks a turning point for an aircraft that was always considered 'interim' – pending the 'B-52 replacement' that SAC has long wanted – but it also simplifies the task of main-

Above: The FB-111A differs significantly from the standard F-111 of Tactical Air Command, notably by having greater fuel capacity. Externally it is identifiable by having long-span wings and a bulge forward of the cockpit.

Above left: The primary strategic weapon of the FB-111A is the Boeing AGM-69 SRAM (Short-Range Attack Missile), one of which is seen here nestled in the aircraft's weapons bay. Two SRAMs is the normal load, with large wing tanks providing the necessary range for a strike mission. FB-111 missions are largely aimed at defence suppression to allow other bombers to attack strategic targets.



Above: The crew of an FB-111A stabilises its craft under a SAC tanker. The crew is contained in an escape capsule rather than sitting on individual ejection seats.

Right: Its primary mission may be to launch nuclear missiles, but the FB-111A retains full conventional bombing capability, as evidenced here by this aircraft making a low-level attack with para-retarded 'iron' bombs. The FB-111s are in the process of being re-worked for TAC use under the F-111G designation.

taining and operating SAC's small force of ageing bombers.

Lurking behind everything that happens in SAC – not yet a part of SAC at all, yet vital to its future – is the bat-like silhouette of the aircraft less assured of funding than any defence project in recent history. The Northrop B-2 stealth bomber, the flying-wing aircraft that will make the SAC bomber force larger and newer, is at the heart of all thinking and planning that goes on throughout Strategic Air Command. SAC's goal is a force of 132 to serve well into the third millennium. But it is more than a goal. It is a cause, a crusade, to SAC leaders, to obtain a B-2 force – at a time when the idea is widely and strongly opposed.

The second B-2 was scheduled to fly at Palmdale, California, in September 1990 (after a slip from an April 1990 date), while in January 1990 the first aircraft (82-1066) was in layup prior to LO (low observables) testing of its 'stealth', or radar-evading, capabilities. At that juncture, the first B-2 had completed eight flights, 31.6 hours of flying time, and several mid-air transfers of fuel from a McDonnell Douglas KC-10A Extender tanker – all without major mishap in a test programme best characterised as exceedingly ambitious.

The US Air Force had hoped to order three B-2s in fiscal year 1991, but received US $1.664 billion for only two B-2s. Plans to deliver the first operational B-2 to Whiteman AFB, Missouri, 45 miles from Kansas City, by early 1991, will be postponed – though SAC will still activate the 351st Bomb Wing at Whiteman (now a Minuteman II wing) as the first B-2 unit before aircraft are delivered.

While the Pentagon initially insisted it needed 132 aircraft to maintain capability to penetrate improved Soviet defences, in April 1990 it announced that it may now request only 75 aircraft to equip two wings, this in this face of the considerable change in East-West relations. Two separate bills in Congress would limit the total buy to 15 airplanes. More to the point, the B-2 evokes a fury of emotion from just about every interest group in the United States, who argue that funds for the B-2 could be better spent on everything from abortion to AIDS.

The US Air Force says the B-2 is the only bomber capable of penetrating Soviet airspace after 2001, at which time the B-1B will be relegated to the stand-off role. The tailless, 172-foot flying wing with a bulge in the centre for crew quarters, is described by pilot Colonel Richard J. Couch as "a very nimble aircraft" and "a lot of fun to fly."

In SAC service, the two-man crew of the B-2 will consist of two pilots, the aircraft commander (AC) positioned in what is normally a subordinate location in the right seat, and the pilot (the term co-pilot is not used) in the left seat. The AC will be responsible for all aspects of getting the bomber to and from its target, but the pilot will do most of the flying – a radical departure in US Air Force procedure that could put a junior officer in charge on B-2 missions.

The two men are located side by side in the unnaturally large bulge in the centre of the flying wing. A third seat is sometimes occupied by an engineer during the test programme and could be used by an instructor for check flights in an operational environment.

Sophisticated controls

The pilot operates the aircraft using digital flight controls. Like many newer warplanes, the B-2 has 'fly-by-wire' (FBW) flight surface controls, although the surfaces may actually be moved by light signals carried by fibre-optic strands – a 'fly-by-light' system. Either way, the controls obviate any need for the pulley and cable, or hydraulic actuators, which move control surfaces on non-FBW aircraft.

It has never been clear, however, whether FBW controls – no matter how well shielded by protective materials – are safe from the electromagnetic pulse (EMP), the flux of electrons that may disrupt electricity and overload systems in the wake of a nuclear explosion. The General Electric DFCS (digital flight control system) apparently controls eight large, simple flaps at the B-2's trailing edge among other flight surfaces.

The prototype Northr B-2 wheels over the California desert duri an early test flight, showing clearly the beautifully-blended surfaces that bestow true 'stealth' capabili on the type. The sunk exhausts are readily apparent, this feature shielding the rear of t engines from radar energy and also masking their heat, making acquisition b infra-red detectors fa more difficult. The quadruplex fly-by-wi flight control system operates the many control surfaces on th trailing edges, includ the split 'drag rudder on the outboard secti which operate differentially for yaw control or simultaneously for a braking (upper and lower sections) and extra lift (lower secti only).

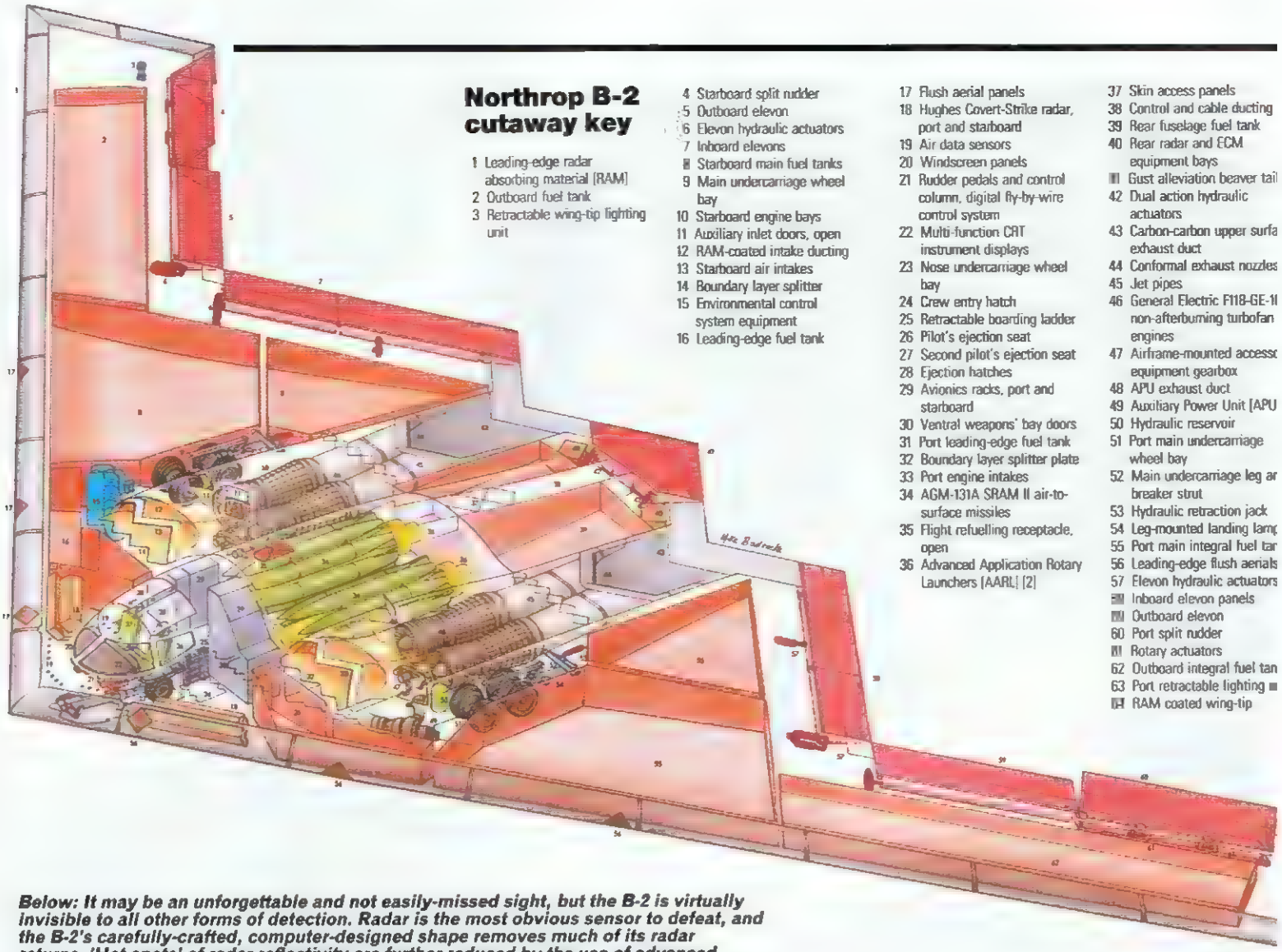
Below: Seen on its s flight, the B-2 hooks to a 22nd ARW KC-1 tanker to demonstra the ease of inflight refuelling. Such is th range performance c the B-2 that the USA says it can reach an spot on the globe fr four worldwide base with only one refuel

The B-2 is powered by four General Electric F118-GE-100 engines. These are non-afterburning powerplants developed from the maker's more familiar F110. Operational B-2s will be fuelled with JP-8 rather than the more volatile JP-4 fuel used at most bases, to reduce risk of losing the expensive aircraft to fire. The kerosene-based fuel, similar to fuel used in commercial jetliners, has a higher flash point and lower vapour pressure than naphtha-based JP-4. Funds permitting, the US Air Force plans eventually to convert most bases to JP-8; the bases in Japan and South Korea have requested a delay until 1995, when they phase out F-86s and T-33s that cannot use the new fuel.

The flying wing design of the B-2 is structurally efficient. With the mass of the airplane spread evenly along the wingspan, rather than at the centre in a fuselage, bending loads are smaller and the wing can be lighter. The wing shape also seems to be the result, rather than the cause, of a low radar cross-section.

Key to the B-2 and its mission is the first large-scale application of stealth or 'low observables' (LO) technology, which seems inextricably linked to the survival of the strategic bomber as a viable weapon. Stealth is the 'mix' of technology that makes the bomber hard to see and hard to detect.

On 20 February 1990, outgoing Air Force chief of staff General Larry D. Welch told Congress that the projected force of B-2 bombers could not prepare for an attack and take off without the Soviets knowing it was coming. But, said



Northrop B-2 cutaway key

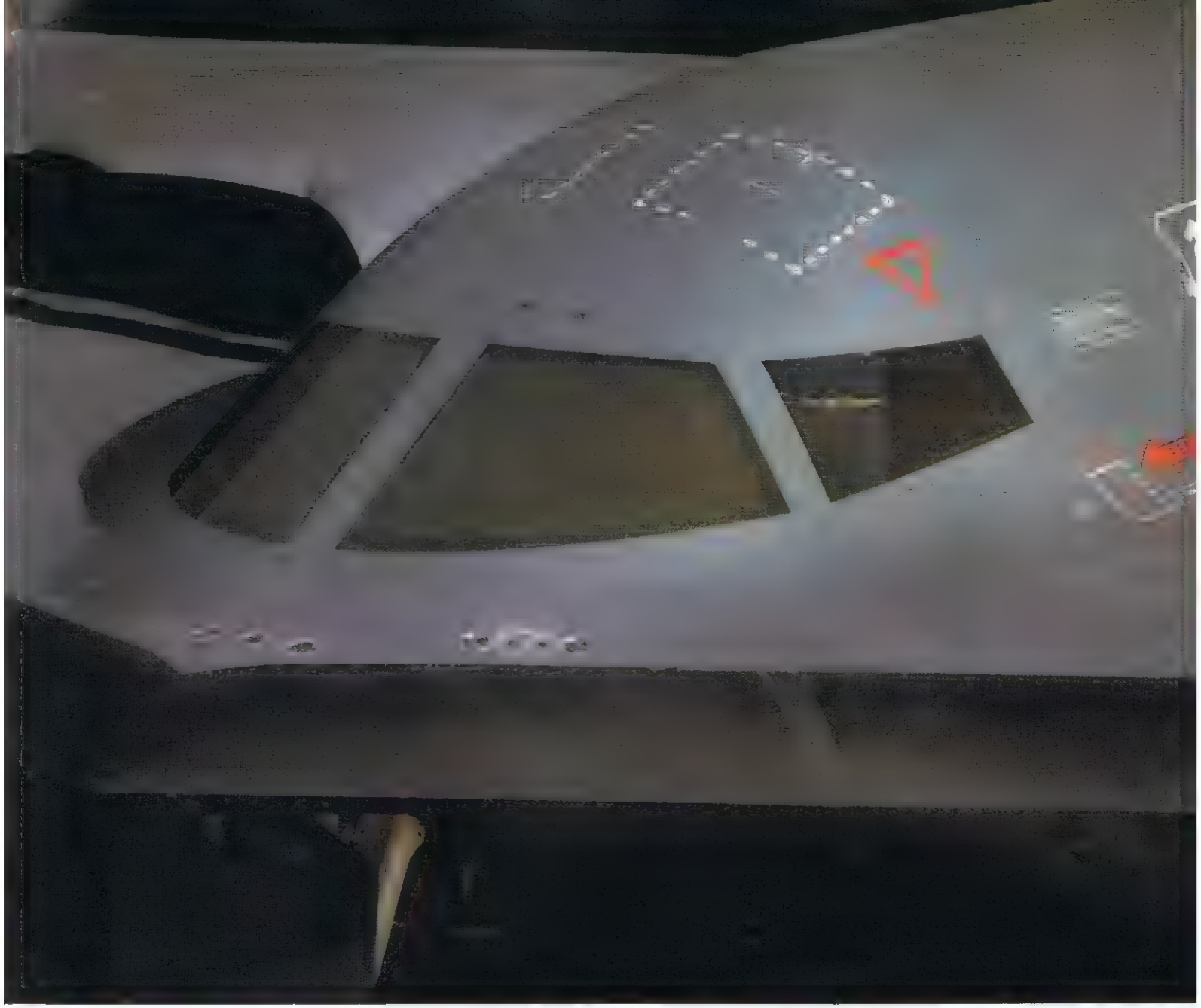
1 Leading-edge radar absorbing material (RAM)
2 Outboard fuel tank
3 Retractable wing-tip lighting unit
4 Starboard split rudder
5 Outboard elevon
6 Elevon hydraulic actuators
7 Inboard elevons
8 Starboard main fuel tanks
9 Main undercarriage wheel bay
10 Starboard engine bays
11 Auxiliary inlet doors, open
12 RAM-coated intake ducting
13 Starboard air intakes
14 Boundary layer splitter
15 Environmental control system equipment
16 Leading-edge fuel tank
17 Flush aerial panels
18 Hughes Covert-Strike radar, port and starboard
19 Air data sensors
20 Windscreen panels
21 Rudder pedals and control column, digital fly-by-wire control system
22 Multi-function CRT instrument displays
23 Nose undercarriage wheel bay
24 Crew entry hatch
25 Retractable boarding ladder
26 Pilot's ejection seat
27 Second pilot's ejection seat
28 Ejection hatches
29 Avionics racks, port and starboard
30 Ventral weapons' bay doors
31 Port leading-edge fuel tank
32 Boundary layer splitter plate
33 Port engine intakes
34 AGM-131A SRAM II air-to-surface missiles
35 Flight refuelling receptacle, open
36 Advanced Application Rotary Launchers (AARL) (2)
37 Skin access panels
38 Control and cable ducting
39 Rear fuselage fuel tank
40 Rear radar and ECM equipment bays
41 Gust alleviation beaver tail
42 Dual action hydraulic actuators
43 Carbon-carbon upper surfa exhaust duct
44 Conformal exhaust nozzles
45 Jet pipes
46 General Electric F118-GE-1 non-afterburning turbofan engines
47 Airframe-mounted accesso equipment gearbox
48 APU exhaust duct
49 Auxiliary Power Unit (APU
50 Hydraulic reservoir
51 Port main undercarriage wheel bay
52 Main undercarriage leg ar breaker strut
53 Hydraulic retraction jack
54 Leg-mounted landing lam
55 Port main integral fuel tar
56 Leading-edge flush aerials
57 Elevon hydraulic actuators
58 Inboard elevon panels
59 Outboard elevon
60 Port split rudder
61 Rotary actuators
62 Outboard integral fuel tan
63 Port retractable lighting
RAM coated wing-tip

Below: It may be an unforgettable and not easily-missed sight, but the B-2 is virtually invisible to all other forms of detection. Radar is the most obvious sensor to defeat, and the B-2's carefully-crafted, computer-designed shape removes much of its radar returns. 'Hot spots' of radar reflectivity are further reduced by the use of advanced RAM (radar-absorbing material). Where these spots are unavoidable, such as inside corners, they are placed in less-vulnerable places, hence the sawtooth trailing edge which is not so critical if illuminated by radar.

Welch, the Soviets could not track the bombers with enou accuracy to stop them. Air Force Secretary Donald B. Ri added that the bomber's stealthy abilities do not rely on single characteristic or system, and foes would require mo than the 'occasional blip' they would get on their radars find the B-2.

Stealth begins with the capability of the flying wi bomber to elude or evade Soviet radars. This begins with t thin flying-wing profile and minimal body, the wing sha deflecting radar waves and reducing RCS (radar cross-se tion). In an earlier generation of stealth aircraft such as t F-117A Nighthawk, importance was placed on coatings radar-absorbing material, or RAM – created from iron cor pounds called ferrites or (as in more advanced aircra polymers made from salts. RAM molecules soak up rad energy and transform it to heat instead of reflecting it. T RAM materials are used with composite of graphite-li substances, mixed with resin epoxies, that are not good r flectors of radar waves.

In a newer era of thinking, RAM, for all its stealth benef has the drawback of adding greatly to the weight of an ai craft. "The F-117A is like a lead sled with a half-inch coati of this stuff all over," says a radar expert. Furthermo RAM does not avoid joints that produce 'hot spots' readi detected on radar. Engineers say that the B-2 was design 'outside-in' so that the actual shape of the B-2 itself, rath than any protective coating of RAM, would reduce its vu nerability to radar. On the B-2, as part of the new thinki and to save weight, the use of RAM may be limited to t coat of paint on the aeroplane.



Because of its small frontal cross-section (its RCS from the front is what matters) the B-2 is difficult or impossible to detect by the high-frequency radars used in fire control systems today. "By the time they detect him it'll be too late," says an expert. The US Air Force is confident that the B-2 is equally difficult to detect by lower-frequency, long-range search radars.

The question has been raised, however, as to whether the bomber is vulnerable to ultra-wide-band radars that may become operational – if technical problems can be solved – by the late 1990s. Tests showed the B-1B to be highly vulnerable to wide-band radar, but were performed with a plastic model rather than an actual aircraft under circumstances that are discounted by US Air Force sceptics.

In theory, since ultra-wide-band radars transmit energy across a broad spectrum, rather than at fixed frequencies (or, in the case of fire-control radars, 'hopping' frequencies), within a wide range band, the B-2 bomber will no longer be impervious to detection. The US Air Force says, however, that developing a defensive network of ultra-wide-band radars would confront the Soviets with two choices, neither of them palatable: the Soviets would have to create a system using enormous power at intolerable cost, or they would have to set up a 'picket fence' of transmitters and receivers along their borders, also unacceptably costly.

Radar, however, is only part of the problem if a stealth bomber is to succeed. Ben Rich, head of the Lockheed team that worked on stealth technology in the F-117A fighter, says that a stealth engineer has "no free lunch," since increasing one type of stealthiness means that other low observable qualities are reduced. For example, the best designs to foil radar may increase the heat signature. After evading radar, the B-2 must seek also to outwit IR (infra-red) detection, which is increasingly important in warfare because of its ability to search without emitting signals.

Among the B-2's repertoire of LOs, one aspect of its stealth vis-a-vis infra-red (IR) is both simple and obvious: engine intakes and exhausts are positioned at the top of the aircraft, making it exceedingly difficult to detect them from below. Exhaust heat and noise are reduced by using bypass engines that mix fresh air with the exhaust gases and by putting heat-absorbing material in tailpipes.

Stealth technology also recognises the importance of the Mk I Eyeball. In the visual realm, the B-2 is said to be able to eliminate its contrails while cruising at altitude, apparently by adding chloro-fluro-sulphonic acid to its exhaust.

If the Russians can't kill the B-2, the budget squeeze can. Despite putting their best face forward, SAC officers have no way of knowing how soon, if ever, their plans for a B-2 force will become reality. At its often-quoted US $530 million per airplane price tag (a figure which includes research and development costs), the B-2 is by far the costliest warplane in history.

Cancelling the B-2 would mean reduction of the bomber force to about 200 aircraft, more than half of which (B-52H) would be older than 40 years, Welch warns. But most in Washington agree with Congressman Joseph M. McDade, who says it is a "fundamental assumption" that the Air Force is not going to get 132 B-2s. Senator Warren Rudman warns that, "It's time to start looking at . . . (a) 'two and a half leg

Although flying-wing technology has been around for years, the combination of that concept with low-observables technology has resulted in an aircraft that bears no resemblance to any other. In order to preserve the blended shape, all sensors and weapons are carried internally. Under the leading edge of the nose are panels through which peers the Hughes LPI (Low Probability of Intercept) radar, which as its name suggests has been designed to present little or no information to a passive detection system. Clearly visible are the frangible panels through which the crew would eject, and the splitter plate that separates the airflow entering the engines from the sluggish boundary-layer on the wing, itself crafted into a sawtooth arrangement to defeat radars.

A 97th BW B-52G leaves a rain-drenched Eaker runway for a transit flight to Andersen AB on Guam. This model has already started a slow withdrawal from service, although this will pick up momentum as Northrop B-2s are delivered, provided the low-observables bomber can make it through a political minefield relatively unscathed. No retirement plans have yet been announced for the B-52H.

Far right, inset: Increasing stand-off capability in the 1990s is the General Dynamics AGM-129 Advanced Cruise Missile, embodying low-observables technology to enhance its ability to penetrate hostile defences. Intended for use initially on the B-52H (as seen here during captive carry tests), the AGM-129 serves first at K.I. Sawyer AFB, Michigan. B-1Bs may be armed with the missile later.

triad,' with the 'half' being the B-1B armed with cruise missiles rather than a penetrating bomber like the B-2."

In addition to having its own intelligence outfit (the 544th) and its own strategic 'schoolhouse' (the STC), SAC has its own annual bombing and navigation competition, Proud Shield, held at Barksdale.

At Proud Shield in 1989, a B-1B was the highest scorer. B-1B crews of the 28th Bomb Wing (Ellsworth) won the Fairchild Trophy, for best combined bombing and navigation scores. The 28th also received trophies as the B-1B unit with the most points in all activity and for being the bomb unit with top scores in activities.

Runner-up was the 380th Bomb Wing from Plattsburgh AFB, New York, which will briefly be SAC's sole surviving FB-111A unit. Fifteenth Air Force won the Lt Gen James H. Doolittle Trophy as the numbered air force with the highest percentage of possible points.

Intelligence, schooling and rehearsals like Proud Shield all prepare SAC people for the eventuality they hope will never come – the real thing.

In wartime as in practice, a SAC bomber mission – by B-1B or B-52 – begins with MITO take-off and follows with the bomber proceeding north at relatively high altitude to conserve fuel, perhaps 33,000ft (9138m). The purpose of MITOs, simply, is to get bombers and tankers aloft as quickly as possible to enable them to survive. In practice, as many as 17 bombers have been put aloft at 12-second intervals.

In a hi-lo-lo-hi profile, the bomber would stay at high altitude until 'topping off' from a tanker at the jump-off point somewhere north of the Arctic Circle. The bomber then enters Soviet air defences at low altitude, literally brushing the face of the earth. The approach to target is made low (as would an approach to second or third targets), after which the egress from defended airspace is made at low altitude.

Circumstances permitting, the bomber succeeds in egress-

'War is our professio peace is our product' SAC's motto has recently changed to reflect the immense a awesome capabilities the force, and to rem the world of the valu deterrence. Like all S personnel, this B-1B crew are trained to perform the deadlies mission on earth, yet they know that their ability to perform tha mission will deter an aggressor from attempting a major attack on the United States and its allies.

ing hostile air space and meets a tanker again for the flight home. Alternate SIOP mission plans probably call for diversion to airfields in Europe.

B-52 pilot Larry Nilssen says: "Without disclosing any secrets, there's a lot of flexibility. If you miss the tanker you stay high and head for tanker option number two. Flexibility is a key advantage of the bomber force. You can vary your speed, altitude, approach routes, and so on.

"A point often missed about manned bomber penetration is that even the first bombers to go in are, in effect, part of the second wave – preceded to the target by Minuteman ICBMs. You could almost fly a 747 over that space, after the ICBMs have gone in, and not have anyone see you. Look at it: the Russians had a lot of trouble getting that Korean Air Lines 747 over Sakhalin. By the time *any* bombers go in, defences are degraded. Lots of confusion."

While piloting the B-1B or B-52 may be exhilarating to the men up front, the unsung heroes of the SAC force are the crew members who sit in the back. The systems operators on a B-1B or the EWO aboard a B-52 are like sardines in a can – blind, battered, and prone. An important part of SAC training is transition work, performing touch-and-go landings at an airfield, and this kind of flying is particularly difficult for the non-pilot crew members.

Nilssen describes the challenge. "Let's say you're . . . moving toward a SIOP target. The other guy has put up half his air force in the form of Flankers, Fulcrums, Foxhounds. He wants to get you. He's got lookdown/shootdown pulse Doppler radar. But by the time he turns it on, you're down in the dirt. Let me tell you something: that pilot of an Su-27, MiG-29 or MiG-31 may be able to pick you out from ground clutter, but he can't get down in the weeds to kill you. You can defeat him every time."

Defeating the defences

The B-1B or B-52 has an excellent chance of foiling an interceptor's radar with ECM (electronic countermeasures) or, at least, defeating a radar-guided missile fired by an inter

A B-52 rolls on to its outrigger at the end of another training mission. The already lengthy career of the B-52 is far from over, with B-52Hs continuing indefinitely in the cruise-carrying role. As one pilot put it, "When they retire the B-1s, they'll fly back from the boneyard in a B-52!"

ceptor. On both bombers, but especially the B-52, engine exhausts are located on the lower portion of the aircraft, making it more difficult for the enemy interceptor pilot to score a kill with an IR missile. (The future B-2, ironically, might be more vulnerable to the Soviet equivalent of a Sidewinder – but only if the bad guys can find it first).

The final option available to the fighter pilot is his gun: at low level, possibly in bad weather or at night, shooting down a B-1B or B-52 flying at low level on TA (terrain avoidance) is anything but an easy proposition.

Though all SAC bombers are stationed on United States soil, they have been frequently seen overseas. B-52s on conventional exercises routinely deploy to Kadena AB, Okinawa, and RAF Fairford, England. Others engaged in maritime operations make quiet appearances at RAF St Mawgan. Says Lieutenant-Colonel R. J. Mills Jr, "They're simply going abroad to practise what they do for a living. It's more a familiarisation to the European operating environment than anything else. No specific requirement exists except to demonstrate mobility."

Though almost never on the ground, B-52s support operations in Korea and West Germany. B-1B overseas appearances have so far been limited to single appearances plus one extended deployment to Guam. Mills says, "Given the current political situation – peace breaking out and the wind-down of the defence budget – they'll be seen overseas far less."

The future of the manned bomber leg of the strategic triad will be decided by civilians, not military men, and may be affected by interpretations of strategic arms agreements. The 'best case' from the viewpoint of SAC officers is a full purchase of 132 B-2 airframes, resulting in a force by 2001 of 316 bombers (132 B-2s, 97 B-1Bs, and 87 B-52Hs with ALCMs), according to figures compiled by House Armed Service Committee Chairman Les Aspin. The 'worst case', should the B-2 be cancelled entirely and the B-1B lose its capability to penetrate, would be zero penetrating bombers, with SAC doing the job entirely as a stand-off mission with ALCMs.

Bomber Units of Strategic Air Command

Strategic Air Command

Strategic Air Command was born on 31 March 1946, when the Continental Air Forces of the USAAF were divided into Tactical Air Command, Air Defense Command, and Strategic Air Command. Ten days later the reactivated 15th Air Force was assigned to SAC, followed by the 8th Air Force on 7 June.

The huge fleets of bombers used during the war had largely been sold for scrap, with the B-17 and B-24 having all but disappeared, and the fleet of some 2,000 B-29s reduced to less than 200. During the early days, demobilisation continued to weaken the new force, so that by the end of 1946 only six of SAC's bomb groups actually had any aircraft assigned, and only 148 B-29s were on strength. Nonetheless, the new organisation was given the vital responsibility for long-range offensive operations, either independently or in support with land and naval forces. The importance of the nuclear role was emphasised on 1 July 1946, when a B-29 of the 509th Composite Group, named 'Dave's Dream', dropped SAC's first plutonium bomb during the tests at Bikini atoll.

As the Cold War began to hot up, SAC responded to the challenge, and in 1947 six B-29s were rotated from Davis-Monthan Field to Rhein-Main near Frankfurt, foreshadowing later, larger deployments by SAC bombers to Europe, which continue to this day. Aircraft strength increased dramatically during 1947, and SAC began to prepare for the arrival of the giant B-36. By 1948 SAC had two B-36 heavy bomb groups (one existing only on paper) and 12 medium bomb groups sharing 521 B-29s and B-50s. It also gained a new commander, General Curtis LeMay, who was to put his stamp firmly on SAC during his 10 years in command, revitalising his force by demanding high standards and professional performance and achieving both by a relentless training schedule and boosting morale. He also presided over a massive growth, so that by the late 1950s SAC had more than 2,000 bombers on strength, most of them jet-powered B-47 Stratojets.

During the next decade the manned bomber strength of SAC began to shrink again, and the force continued to soldier on without any major re-equipment programmes. The Mach 2 Convair B-58 was procured in small numbers, and enjoyed only a brief service life, while the Mach 3 B-70 never entered service at all. The B-52 was left to form the backbone of America's manned bomber force even after the introduction of the B-1B and FB-111.

Today, Strategic Air Command is headquartered at Offutt AFB, Nebraska, having moved there from Andrews AFB on 10 November 1948, an airfield since 1921 but previously the US Army's Fort Crook. It comprises two numbered Air Forces, with the Eighth Air Force responsible for units on the Eastern side of the USA and the Fifteenth responsible for Western units.

SAC is now going through major changes, with the impending transfer of the FB-111 to TAC, the gradual retirement of the B-52G and the forthcoming service entry of the Northrop B-2 Advanced Technology Bomber. The 16 Bombardment Wings currently in service comprise two with the FB-111A, four with the B-1B, four with the B-52H and six with the B-52G.

Eighth Air Force

The Eighth Air Force was originally formed as VIII Bomber Command on 19 January 1942, soon moving to England where it was re-designated as the Eighth Air Force on 22 February 1944. The Eighth flew over 600,000 sorties against Nazi Germany, dropping over 700,000 tons of bombs and destroying more than 15,000 enemy aircraft. After the defeat of Germany the 8th transferred to Okinawa, but the war ended before it could go into combat against Japan.

On 7 June 1946 the 8th was transferred from US Army Forces Pacific to SAC, with the headquarters moving to MacDill Field, Florida, and then, on 1 November, to Fort Worth Army Airfield (later known as Carswell AFB). Later the headquarters moved to Westover AFB, Massachusetts, on 13 June 1955, and to Andersen AFB, Guam, on 1 April 1970. The latter move was made without personnel or equipment and was effectively a redesignation of the 3rd Air Force, undertaking bombing missions in Vietnam. The Headquarters transferred, again without personnel or equipment, to Barksdale AFB to replace the deactivated 2nd Air Force on 1 January 1975. Today the 8th controls four air divisions and 18 wings, and its task is officially described as being:

"To command and administer aircraft, missiles and forces assigned by CINCSAC to 8th AF; achieve and maintain the level of alert force readiness directed by CINCSAC; organize, train, equip, and deploy through a SAC Advance Echelon those elements necessary to conduct conventional long-range bombing operations, IAW operations, plans and to exercise operational control of SAC assets in the 8th AF areas of responsibility; and provide aerial tanker support for deploying forces as directed by CINCSAC."

8th Air Force has a greater number of B-52s assigned to it compared to the 15th, but only one B-1 wing. It also controls all the FB-111As until they are handed over to Tactical Air Command.

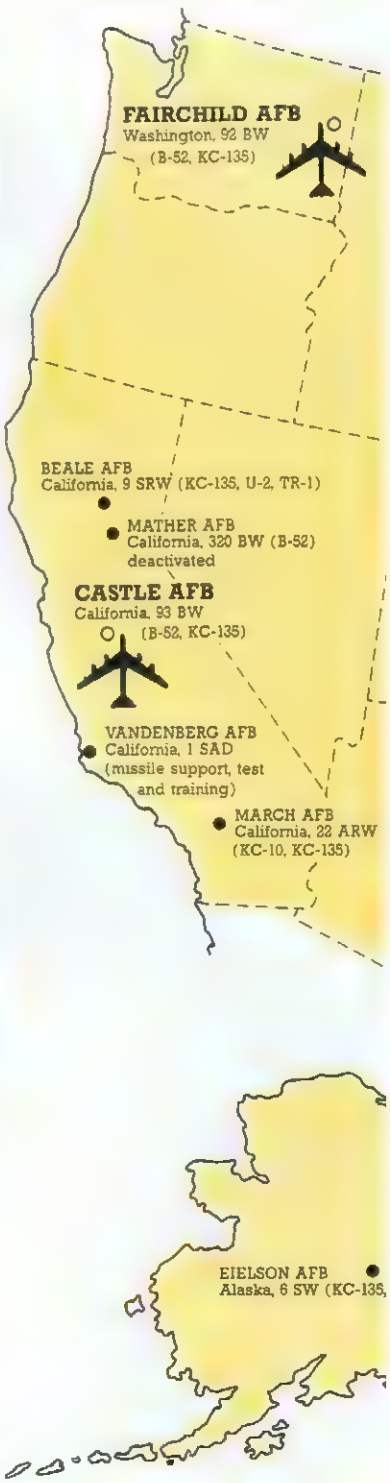
Fifteenth Air Force

The Fifteenth Air Force was activated on 1 November 1943 in Tunisia, and began flying combat missions from North African bases. The HQ moved to Bari, Italy, in 1943. The 15th was deactivated on 15 September 1945, then reactivated as the first of SAC's numbered air forces on 31 March 1946 at Colorado Springs.

The 15th AF created and trained a strategic bombing force of B-29s and B-50s, which were later used for conventional bombing missions in Korea. HQ moved to March AFB on 7 November 1949. The responsibilities of the 15th grew steadily, taking on air-refuelling assets during the 1950s, ICBMs from 1960, all SAC airborne reconnaissance units during the 1960s and the SAC Airborne Command Post in 1973. Between 1965 and 1973, 15th Air Force bombardment wings picked up a dual mission, the support of the war effort in South East Asia while maintaining a nuclear deterrent capability. Today the 15th controls four air divisions and 18 wings, and its task is officially described as being:

"To command and administer aircraft, missiles and support forces assigned by CINCSAC to 15th AF; achieve and maintain the level of alert force readiness directed by CINCSAC; organize, train, equip, and be prepared to deploy and employ through a SAC Advance Echelon those elements necessary to conduct conventional long-range bombing operations, in accordance with US Commander-in-Chief Pacific operations plans; organize, train and equip reconnaissance forces and be prepared to conduct SAC long-range reconnaissance operations; and provide aerial tanker support for deploying forces as directed by CINCSAC."

A vital task assigned to 15th Air Force is the training of B-52 and tanker crews, undertaken by the 93rd BW at Castle AFB. Other 15th AF specialities are strategic reconnaissance and the majority of B-1 operations.



Above: SAC crews maintain a fierce pride in their task, combat effectiveness being kept to a high by regular competitions.

Right: The mailed fist grasping an olive branch of SAC is one of the best-known military insignia.

Strategic Air Command is divided into the 8th and 15th Air Forces, and the United States is roughly divided down the middle with responsibilities to the West assigned to 15th AF and those to the East assigned to 8th AF. The Air Force division adheres to state borders apart from dividing Texas in half. Strategic bomber bases are located in three main areas. Two wings fly from the West coast, four fly from the north east, close to the European theatre, while the vast majority are located in a wide band that runs through the central United States. These are located here for strategic purposes, their security being of vital importance to a retaliation effort. By placing them in the centre of the United States, the majority of bases would have ample warning of a surprise nuclear attack, and be able to launch their bombers before any incoming weapons arrived. Similarly the SAC missile bases are also inland. Other SAC bases mentioned perform tanker or reconnaissance

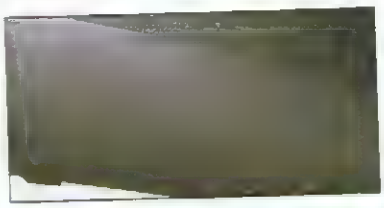
2nd Bombardment Wing

Motto: 'Libertatem Defendimus' (We Defend Liberty)

The 2nd BMW is based at Barksdale AFB, Louisiana, and maintains a combat-ready force of B-52Gs and KC-135 tankers 'sufficient to ensure global target acquisition'. Its two bomber units are the 62nd Bomb Squadron and the 596th Bomb Squadron. The aircraft from the 62nd Bombardment Squadron have a conventional mission, while those from the 596th are equipped with the ALCM. As well as being directly tasked to support SAC's Single Integrated Operational Plan (SIOP) the wing has an additional mission of conventional bombing and provides KC-10s tasked with a Rapid Deployment Force role. Most Barksdale B-52s wear a small black 'Fleur de Lys' on their tailfins, with 'Barksdale' in old English script on the fuel tanks.

The Wing has a long and proud history, having had its origins in France during World War I, before taking part in Billy Mitchell's famous demonstrations against battleships. It was the first B-17 unit, and served in North Africa and Italy during World War II. The 2nd became a SAC 'Super Wing' in 1968, when it gained a second B-52 squadron. Four B-52Gs are to be retired during mid-1990.

SAC bombers carry a toned-down version of the wing badge on the port fuselage side. On the starboard side is the SAC badge.



Below: One of the 2nd BW's squadrons has an ALCM-carrying role, as evidenced by this B-52G fitted with wing root strakelets.

Below: 'Big Shmoo' is from the 62nd BS, the 2nd BW's conventional bombing squadron. The unit regularly deploys aircraft to Europe. Note the black fleur-de-lys emblem on the fin.

5th Bombardment Wing, Heavy

Motto: 'Kiai O Ka Lewa' (Guardians of the Upper Realm)

The 5th BMW is based at Minot AFB, North Dakota. Its single B-52H unit is the 23rd Bombardment Squadron, whose complement of 17 aircraft is to reduce to 14 in mid-1991, when three B-52Hs are due to transfer to the 416th BW. Its mission is to conduct strategic warfare in accordance with the SIOP and taskings specified in the Emergency War Order. The 5th BMW is also the spearhead of the Strategic Projection Force and regularly deploys overseas, proving its ability to conduct operations from remote locations. The wing's tail insignia is a winged skull.

The wing spent its first years in Hawaii, on one occasion bombing an advancing lava flow to save a local town and its water supply from devastation. This feat is celebrated in the 23rd Bombardment Squadron's badge. Later the unit lost several aircraft during the raid on Pearl Harbor but went on to participate in the Battle of Midway, when its B-17s scored direct hits on a number of enemy ships. The wing spent the whole war in the Pacific, as part of the 13th 'Jungle Air Force'.

After service as a B-36 unit, the 5th BMW entered the jet age in 1959, when it received its first B-52G at Travis AFB. The wing moved to Minot in July 1968, where it re-equipped with the B-52H. These aircraft were used in 'Arc Light' and 'Linebacker II' missions. The wing received the AGM-69A SRAM in 1975, enhancing the ability of the ageing B-52Hs to penetrate enemy defences. In 1983 the wing completed conversion to Offensive Avionics System (OAS) modified B-52s, this programme replacing vacuum tube technology avionics with computerised circuitry.

In 1988 the 5th BMW won the Riverside Trophy (Best Wing in 15th AF), the Art Neely Trophy (Best Bomb Wing in 15th AF), while the 23rd BMS carried off the Outstanding Bomb Squadron and Bomber Crew of the Year awards. In the SAC Bombing and Navigation Competition the 23rd BMS won the Fairchild Trophy (Best Bomber Unit), the Crumm Trophy (Best High Altitude Bombing) and the Best B-52 Crew award. 1988, which included deployments to Ellsworth and Hickam, was rounded off by the award of an Outstanding Unit award.

In 1989 the wing repeated its successes in the Riverside and Neely Trophies, and again gained Outstanding Squadron and Crew awards. In the annual SAC contest the 23rd BMS again scooped the Best B-52 Crew award. Deployments were made to Hickam and Eielson. 1990 has already included deployments to Andersen AFB, Guam, and to RAAF Darwin, Australia and to Nellis AFB for Red Flag 1990-3.

The 23rd BS badge commem the squadron's volcano-bomb exploits in Hawaii.

Below: A B-52H of the 23rd BS flies past Mount McKinley, Alaska, the highest point in the United States.

7th Bombardment Wing, Heavy

Motto: 'Mors Ab Alto' (Death from on high)

The 7th BMW is based at Carswell AFB, Texas, with 35 B-52Hs assigned to the 9th and 20th Bombardment Squadrons. Four are to be re-assigned to the 416th BW in mid-1991. The wing's aircraft are capable of delivering the Boeing AGM-86B Air Launched Cruise Missile, and will re-equip with the AGM-129 Advanced Cruise Missile. Tail markings consist of a Texas longhorn head superimposed on a black and green, bastardised version of the State flag. As the 7th Bombardment Group the unit fought from bases in Java and India with B-17s and B-24s. After the war the wing operated the B-29 and B-36 before re-equipping with the B-52 in 1957. B-52Fs gave way to B-52Ds in 1970, and to B-52Hs in 1982.

Below: B-52Hs are slowly adopting this sinister all-over dark grey camouflage, in place of the three-tone scheme.

Above: Nose art, 7th Bomb Wing style. Note the map of Texas below the aircraft serial and wing badge.

Below: Leaving the name of their home state in no doubt, the 7th BW's fin badge is a longhorn ste

Below: The 7th Bomb Wing is assigned, like other B-52H users, to the cruise missile carrying role. It is one of the larger wings in SAC, with two squadrons operational.

28th Bombardment Wing, Heavy

Motto: 'Guardian of the North'

The 28th Bombardment Wing at Ellsworth AFB, South Dakota, has two B-1B units, the 37th Bombardment Squadron and the 77th Bombardment Squadron. The B-1B force is armed with a variety of gravity bombs and with the SRAM. The aircraft is ALCM capable (with slight modifications to the bomb bay), although it is believed that the wings do not actually have the missiles on charge.

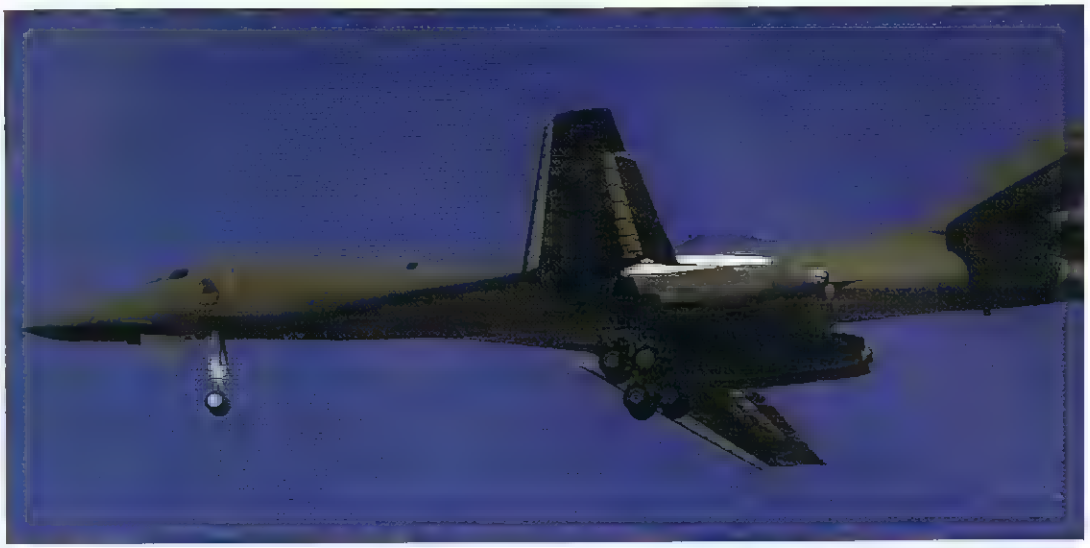
After service in Alaska during World War II, the 28th BMW received B-29s, and in 1949 B-36s. It used these in the global strategic reconnaissance role. B-52s arrived in 1957, and these were used in Vietnam. OAS-equipped B-52Hs gave way to the Rockwell B-1B in 1987.

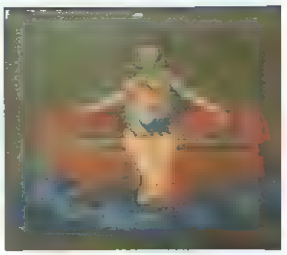
The 37th Bombardment Squadron in particular has enjoyed great success with its new B-1Bs. Its Bengal Tiger badge, symbolising the unit's high proficiency and accuracy, is doubly appropriate. In a 1989 evaluation, the unit gained the best ever bomb and SRAM scores, and won SAC's

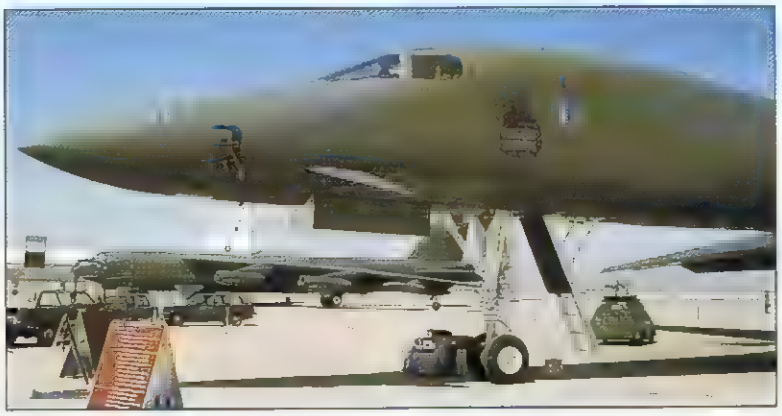
Omaha Trophy awarded to the top wing, as well as the Fairchild, Crumm and Eaker (best B-1B unit) Trophies as well as the prestigious Ryan Award (Best Bomb Squadron in SAC).

The 28th Bomb Wing swept th board in recent SAC competiti illustrating not only the skill le of its crews but also the capabilities of the B-1B.

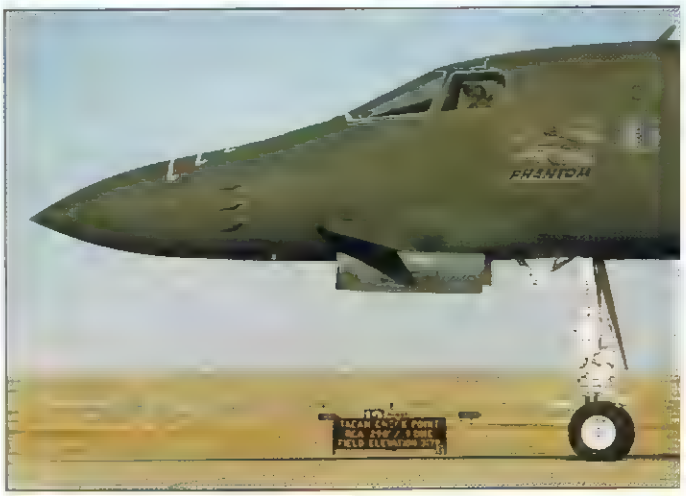
The 28th Bomb Wing not only operates B-1B bombers, but has KC-135R tankers as well. It also operates EC-135 command posts.







Nose art has returned to Strategic Air Command in a big way, the 28th Bomb Wing displaying a typical selection. The two bomber squadrons have 30 aircraft assigned.



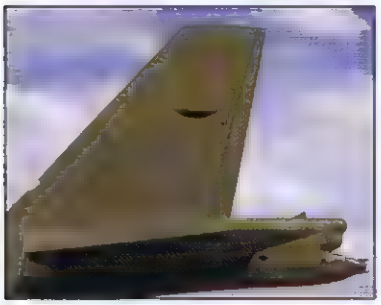
42nd Bombardment Wing, Heavy

Motto: 'Aethera Nobis' (With us the heavens)

Dedicated to the conventional role, the B-52Gs of the 69th Bombardment Squadron, 42nd Bombardment Wing, are capable of carrying the AGM-84A Harpoon anti-shipping missile, mines, and various bombs. The wing is based at Loring AFB, Maine. Tail markings consist of a black moose's head, with blue eyes and a blue bomb in its mouth. Sometimes this is superimposed on a map of Maine. 'Loring' is often written on the tanks. The 42nd was originally a B-26- and B-25-equipped Medium Bomber group, flying in the Pacific. The wing converted to the B-52 from the B-36 in 1956, upgrading to the B-52G in the 1960s.

There have been several variations on the 42nd Bomb Wing's tail markings, but all involve the moose. This one has the animal superimposed on a map of Maine.

Below: Another moose-head on a 42nd BW aircraft, this time holding a bomb in its mouth.



Above: Due to its geographic position, the 42nd Bomb Wing is a natural for Atlantic maritime missions. Its aircraft are cleared to carry AGM-84 Harpoon anti-ship missiles, and are used for surface surveillance and mine-sowing operations. Note the base name painted on the wing fuel tank.

Right: The B-52's nose has sprouted many 'warts' since it first appeared. Note the flush ram air inlet for cooling the avionics bays.

43rd Bombardment Wing

Motto: 'Willing, Able, Ready.'

Deactivated on 30 April 1990, the 43rd BMW has been based at Andersen AFB, Guam, since 1970. The B-52Gs of the 60th Bombardment Squadron were Harpoon-equipped after 1985, and also carried a variety of mines. Tail markings consisted of a palm tree with bombs replacing the more normal coconuts. The aircraft have been re-assigned to various US-based Bombardment Wings.

Above: The palm tree adorned the fin of 60th BS aircraft. The inscription reads 'No Buff too Tuff'.

Badge of the 60th Bomb Squadro

Left: Personnel of the 60th Bomb Squadron pose by 'Old Soldier', one of their B-52Gs, prior to the unit's deactivation on 30 April 199 The unit had conventional tasks assigned, as indicated by the bombload carried on the old Hound Dog pylon. Harpoon missiles were also used.

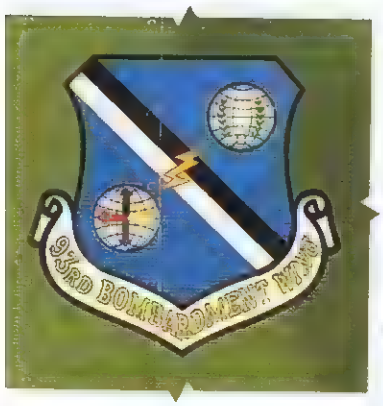
92nd Bombardment Wing, Heavy

The Fairchild AFB, Washington, based 92nd BMW's sole bomber unit is the B-52H-equipped 325th BMS: the aircraft are capable of firing the ALCM. Three B-52Hs are to be re-assigned to the 416th BMW in mid-1991. Fairchild-based B-52s wear a stylised sea hawk head on their fins. After service in Europe with the 8th AF flying B-17s, the 92nd BMW was reassigned to SAC in 1946 with B-29s, converting first to B-36s and in 1956 to the B-52.

'The Seahawks'
Motto: 'Duplum Incolumitatis'
(Double Safety)

The 92nd Bomb Wing carries a stylised 'Seahawk' badge on the fin, 'borrowed' from the Seattle-based football team.

93rd Bombardment Wing, Heavy



Above: Reflecting the base name, 93rd Bomb Wing B-52s wear a castle emblem on the fin. The base was named after Brig Gen Frederick Castle, a B-17 pilot and Medal of Honor winner.

Patch worn by SAC aircrew.

This 93rd patch reflects the training role of the unit.

The primary role of the 93rd BMW at Castle AFB is the training of B-52 aircrew, using 25 B-52Gs of the 328th Bombardment Training Squadron and the 329th Combat Crew Training Squadron. The 329th (previously the 4017th) CCTS flies some 700 B-52 and KC-135 sorties each year, training over 1,000 new SAC warriors. It is responsible for initial training of all crew members, and for upgrading pilots to aircraft commanders and navigators to radar navigators. It also provides refresher training for aircrew returning to the B-52. Aircraft wear a castle tower in grey on their tailfins.

The first B-52 wing in SAC when it formed in 1955, the 93rd BMW had a proud record as the most active group in the 8th AF Europe during World War II, flying [illegible] and other missions with B-24s [illegible] in the raids on [illegible]. The 93rd BMW is due to lose four [illegible] next summer.

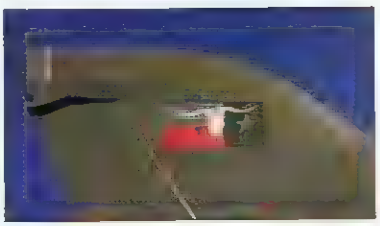
Right: 93rd B-52Gs often fly endless patterns to train crews in the art of landing the 'Buff'. When Castle's pattern is full, other bases are used.

Above: Aircraft are rotated through the 93rd Bomb Wing to avoid excessive airframe hours being accrued. Consequently nose art is rarely applied. However, the aircraft do carry names.

96th Bombardment Wing, Heavy

Motto: 'E Sempre L'Ora' (It's always the hour)

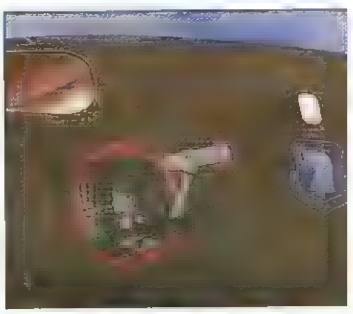
Based at Dyess AFB, Abilene, Texas, the 96th BMW was the first SAC wing to re-equip with the B-1B. The 337th BMS is the operational unit, and is partnered by the B-1B training unit, the 338th Combat Crew Training Squadron (previously the 4018th CCTS). Proud of its Texan links, the wing badge worn on the aircraft consists of a longhorn skull superimposed on the flag of the 'Lone Star' State. The 96th BMW served with distinction with the 8th Air Force during World War II, flying missions against Regensburg, Schweinfurt and Poznan, as well as some of the first shuttle-bombing missions, which recovered to bases in the Soviet Union. After flying B-47s and B-52s, the wing received the B-1B on 29 June 1985.



The 'Lone Star' state flag is carried proudly on the fins of 96th Bomb Wing aircraft.

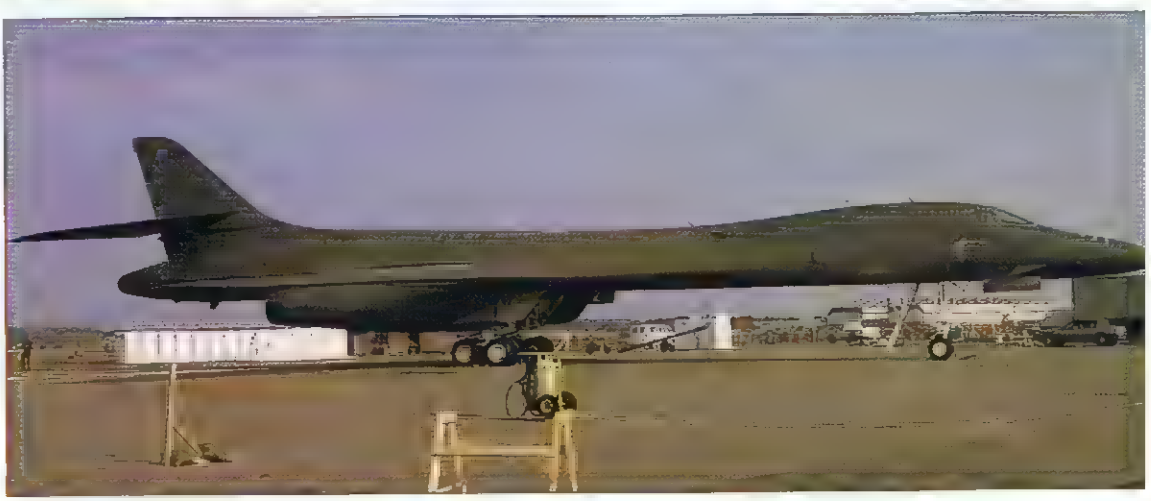
338th CCTS instructor patch.

Dyess AFB Operations patch.



A selection of 96th Bomb Wing nose art, photographed on the Dyess ramp.

338th CCTS squadron badge.

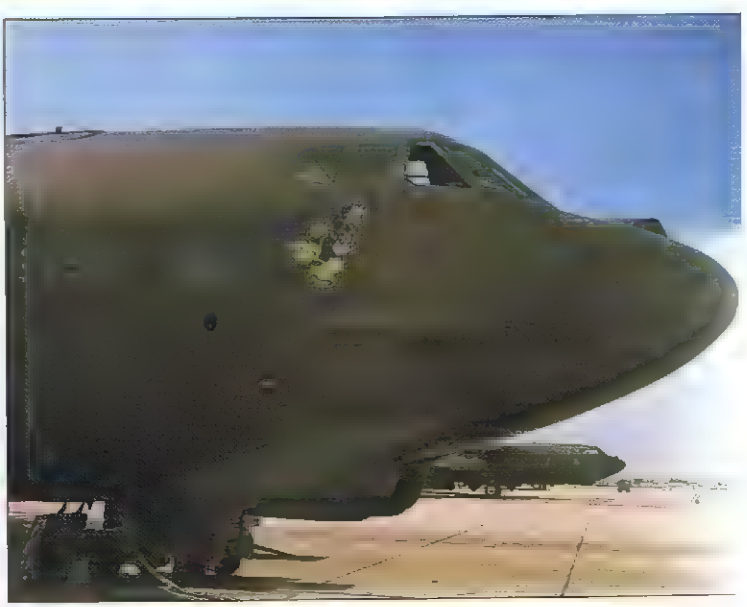


97th Bombardment Wing, Heavy

Motto: 'Venit Hora' (The hour has come)

Eaker AFB (previously known as Blytheville) has recently been threatened with closure, and its future remains uncertain. The resident 97th BMW, with its 340th BMS, is due to lose two of its aircraft during 1990. The wing operates the B-52G, and is equipped with the ALCM. Aircraft wear a toned-down 'flaming spear' marking. Following wartime service in England the wing flew B-29s, then ERB-29s and RB-50s in the reconnaissance role. Reverting to the bomber mission, the unit flew B-50s, B-47s and then B-52s.

'Big Stick' and 'Dogpatch Express' are two of the 340th BS B-52Gs.



Above: The flaming spear wing badge is carried in toned-down markings on the fuselage side.

Right: Lined up at Eaker AFB, the B-52Gs of the 97th Bomb Wing are equipped to launch AGM-86B ALCMs. The B-52G is not scheduled to get the AGM-129.

319th Bombardment Wing, Heavy

Based at Grand Forks AFB, North Dakota, the 319th BMW is the third of the USAF's B-1B wings. The 46th BMS received 16 aircraft during 1988. Aircraft wear a blue and orange sun motif on their tailfins. The wing originated as a light bomber group, and was one of SAC's F-84 fighter bomber wings before disbanding in 1957. Reactivated in 1963, the wing flew B-52s of various types until it re-equipped with the B-1B. It won many prestigious trophies during its time with the B-52, while also acting as part of the Strategic Projection Force until 1982, when it received the ALCM and OAS modifications.

Motto: 'Defensores Libertatis' (Defenders of Liberty)

Grand Forks aircraft have a distinctive fin motif.

Sixteen B-1Bs are operated by the 319th BW's 46th Bomb Squadron.

Above and below: A 319th BW B-1B displays the large slats and flaps that give the type good low-speed handling.

320th Bombardment Wing, Heavy

Motto: 'Strength Through Awareness'

The 320th BMW, based at Mather AFB, California, with the 441st BMS, has now deactivated, and the 'California bear' tail emblem is now only a memory. Their B-52Gs had a conventional mission and were Harpoon-capable. In fact, the 320th was the lead unit in trials to determine the compatibility of the B-52G with the AGM-84 Harpoon, undertaking test firings in 1983. The 320th BMW was unique in the last years of its existence in not having a tanker wing, although an AFRes KC-135E squadron was co-located at Mather. The wing started life as a UK-based B-26 group, going on to fly the B-29 and B-47 before re-equipping with the B-52 in 1963.

Sitting on the Mather ramp, this 320th BW B-52G wears the unit's bear emblem on its fin. This is derived from the California state animal. The 320th was a conventional bombing unit, and undertook trials with Harpoon missiles. Although it lacked a tanker squadron of its own, the 940th ARG of the Air Force Reserve shared the same ramp.

379th Bombardment Wing, Heavy

Motto: 'Diligentia Et Accuratio' (Diligent and Accurate)

The 524th BMS operates 15 B-52Gs from its Wurtsmith AFB, Michigan, base, and has been operational with the ALCM since 1982. Aircraft wear a 'K' in a triangle on their fins, the marking originally used by the group's B-17s while flying from Kimbolton, England, in 1943. After wartime service with the 8th Air Force in England, the 379th reactivated with B-47s and subsequently re-equipped with the B-52 in June 1961.

Right: 'Special Delivery' carries a typically flamboyant nose artwork, although its role today involves the use of missiles rather than bombs.

Below: 379th aircraft wear a large 'K' on the fin, surrounded by a triangle. This alludes to the wing's operations during World War II, as part of the 8th Air Force raids on Europe.

380th Bombardment Wing, Medium

Motto: 'Strength and Confidence'

The three squadrons of the 380th BMW at Plattsburgh AFB, New York, are the 528th Bombardment Squadron, the 529th Bombardment Squadron and the 530th Combat Crew Training Squadron. Wing badge is a red 'Big Apple', reflecting the location of Plattsburgh. These units are equipped with some 35 General Dynamics FB-111As, which are presently being rotated through the Sacramento Air Logistics Center for conversion to F-111G standards for further service with TAC. When the conversion programme is complete the wing will deactivate, although no date for this has yet been announced. The last FB-111As are to be with TAC by the end of FY1992, however. After service as a B-24 unit in the Pacific, the 380th flew B-47s and B-52s, before re-equipping with the FB-111A in 1971. As a B-47 unit, the 380th BMW acted as an experimental 'Super Wing' and at one stage had over 70 bombers (plus 40 KC-97 tankers) on charge.

Above: The pierced 'Big Apple' insignia adorns the fins of 380th BW aircraft.

A selection of 380th Bomb Wing nose arts. Many of the artworks were previously applied to the wing's B-24s during service in the Pacific campaign during World War II. The 380th is unique in SAC in having three bomber squadrons, although one is assigned to conversion training.

Left: This portrait of a 380th BW FB-111A shows the bulge ahead of the cockpit which identifies this strategic version of the swing-wing bomber. Note also the extended tail bumper which prevents damage to the jetpipes during take-off.

Below: The undercarriage begins its retraction sequence as this 380th BW aircraft lifts off in 'burner. The main wheel door moves forward to allow the undercarriage to swing forward, increasing drag briefly before closing.

384th Bombardment Wing, Heavy

Motto: 'Keep the Show on the Road'

The 384th BMW was the fourth and last B-1B unit, with the 28th Bombardment Squadron receiving its complement of B-1Bs at McConnell AFB, Kansas, during 1988. War service with B-17s in England was followed by periods with the B-47 and as a tanker wing. It was re-designated as a Bombardment Wing in 1987, in preparation for the arrival of the B-1B.

The 28th Bomb Squadron of the 384th Bomb Wing was the sixth and last B-1B squadron to form, now equipped with 16 aircraft at its McConnell AFB, Kansas, base. The wing had previously been the 384th Air Refueling Wing, the first recipient of the re-engined KC-135R tanker.

410th Bombardment Wing, Heavy

The 410th BMW is the parent unit of the 644th Bombardment Squadron, which claims to be SAC's biggest and best! Its ALCM capable B-52Hs fly from K.I. Sawyer AFB, Michigan, and were the first SAC B-52s to be equipped with the AGM-69A SRAM (in 1973) and the Electro-optical Viewing System. In 1986 offensive avionics system modifications were completed, enhancing the aircraft's mission accuracy and reliability. Three aircraft are to be transferred to the 416th BMW during mid-1991, but to compensate the wing can look forward to deployment of the new 'stealthy' AGM-129 Advanced Cruise Missile, which will further enhance its ability to penetrate enemy defences. This is apparently already present at K.I. Sawyer, though not yet operational. Tail marking is a stylised rainbow. War service with the 8th Air Force was followed by a long period of inactivity, broken by a brief spell as an ICBM unit. Finally, in 1963, it received B-52s.

Right: The 644th Bomb Squadron has been flying B-52s for 27 years, and now has the B-52H in the AGM-86 carrying role. The badge shows the Bald Eagle, the US national bird.

Below: Resplendent in its new all-over grey scheme, a 410th BW B-52H lands at Nellis during a 1990 'Red Flag' exercise. B-52s are regular participants, lending a further degree of variety to the realistic scenarios.

416th Bombardment Wing, Heavy

Maintenance crew information is carried on a silhouette of the New York state map.

Badge of the 668th Bomb Squa

The nine B-52Gs of the 668th BMS, 416th BMW, are ALCM equipped, but also have an important conventional role. (The 668th BMS was the first operational unit equipped with the AGM-86B Air Launched Cruise Missile.) The wing has demonstrated numerous 'surge' efforts simulating massed conventional attacks and has deployed to various austere 'bare base' airfields. The unit has also been at the forefront of development work, and tested and evaluated the new B-52 Digital Automatic Flight Control System. The B-52Gs are to be retired during 1990, to be replaced by 13 B-52Hs given up by the 5th, 7th, 92nd and 410th BMWs. The retirement of the B-52G will bring to an end 27 years of service with this variant. Tail markings are large and colourful by today's standards, consisting of a large Statue of Liberty in black and grey, with and orange flame. Grey stripes and the word 'Griffiss' are also carried.

The wing had its origins as a light bomber unit based in England, reactivating as a B-52G wing in 1963. Crews supported the SAC effort in South East Asia.

Right: The 416th BW carries perhaps the most flamboyant fin markings in SAC, the huge Statue of Liberty.

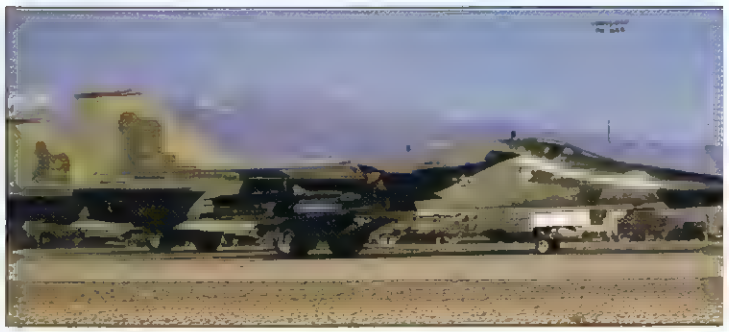
509th Bombardment Wing, Heavy

Motto: 'Defensor Vindex' (Defender and Protector)

This, the first SAC FB-111A wing, started to run down during June 1990, and operations are to cease on 30 September 1990. Pease AFB is scheduled to close soon after that. Rumours suggest that the 509th will become the first B-2A unit, based at Whiteman AFB, Missouri. The 509th consists of two units, the 393rd and the 715th Bombardment Squadrons, and aircraft carry a map of New Hampshire on their tails. The wing originated as the 509th Composite Group, formed for the dropping of the A-bombs on Hiroshima and Nagasaki. Post-war, the unit was a B-47 wing until it converted to the B-52 in April 1966.

This rear view of a 509th Bomb Wing FB-111A displays the electronic countermeasures antennas carried around the jetpipes. On top of the fin is a further fairing concerned with infra-red countermeasures, facing rearwards to ward off attacks by heat-seeking missiles.

Above: Long range tanks are carried by this 509th BW aircraft, a standard fit for nuclear penetration missions. Note the unit's fin marking, a silhouette of the New Hampshire state map.



Left: For many years FB-111As wore this three-tone tactical camouflage with light undersides.

Above: A pair of FB-111As from 509th BW take off from Nellis during a 'Red Flag' exercise.

Air Force Flight Test Center/NASA

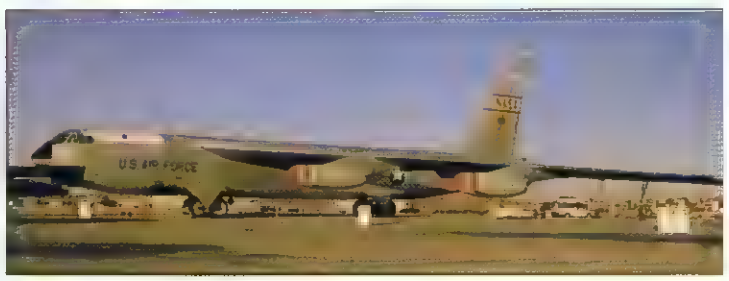
Not part of the SAC organisation, the AFFTC comes under the control of Air Force Systems Command. Based at Edwards AFB, California, the AFFTC has the 6512th Test Squadron as its main flying unit. Among the many aircraft operated are two B-1Bs, a B-52G and a B-52H, all used for permanent test work associated with either the aircraft type or new strategic bombing weapon systems. The AFFTC also has a separate unit assigned to testing the Northrop B-2, also at Edwards.

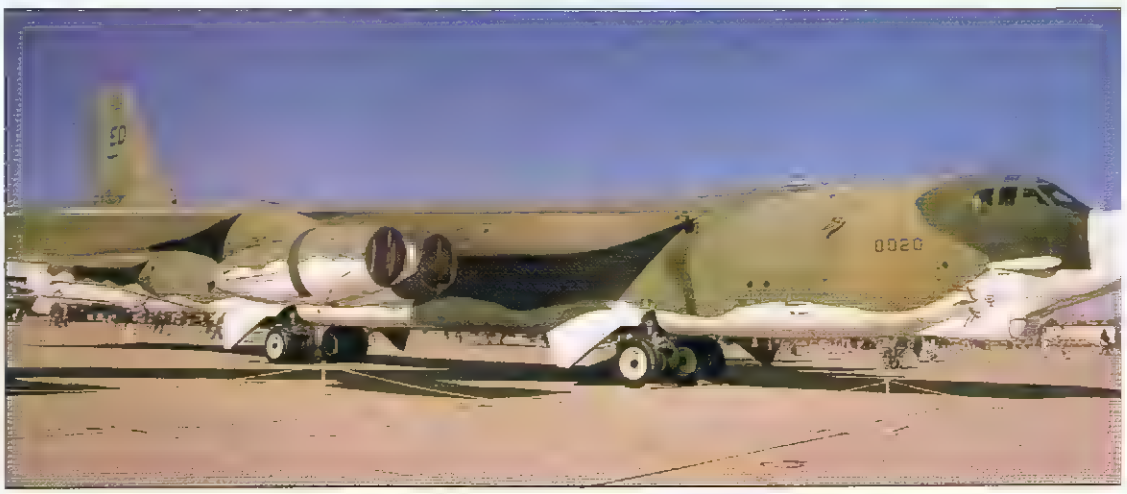
Another Edwards operator is NASA, which maintains the Hugh L. Dryden Flight Research Facility. Among the diverse aircraft assigned to this unit is a single Boeing NB-52B, originally used as launch vehicle for the North American X-15 and still operated in the air-drop role. Its current programe is the Pegasus.

Below: Two B-1Bs are assigned to permanent test work with the 6512th TS, wearing 'ED' codes. This one is seen with weapons bay doors open.

Right: NASA's Hugh L. Dryden Flight Research Facility at Edwards AFB operates Boeing NB-52B 52-008 as a launch vehicle. It is currently used for air-dropping the Pegasus.

Below: A pair of B-52s serve with the 6512th TS, one B-52G and one B-52H (illustrated). Both wear 'ED' tailcodes.





Refuelling recptacle open, and EVS sensors rotated into position, an ALCM-configured B-52G of the 97th Bomb Wing approaches a tanker for refuelling. Each Bomb Wing within SAC has a tanker unit assigned to support the bombers, equipped with KC-135A, KC-135R or KC-10A aircraft. SAC also has six dedicated Air Refueling Wings.

Roya

The principal aim of the **Al Quwwat al Jawwiya al Malakiya al Urduniya** *(RJAF) is to provide air defence against attacks from the west (Israel) or north (Syria), with the Mirage F1 the most potent equipment currently available. One drawback Jordan faces is that its air bases are located very close to the threatening borders, and would be easy to attack with surprise.*

Jordanian Air Force

Photographs by Peter Steinemann

Jordan is in the centre of the crucible of Middle East politics, treading a tightrope between Israel, Syria and Iraq. Only Saudi Arabia is considered a stable ally, although the nation has close military ties with Iraq. Naturally, security surrounding the small yet efficient force is high.

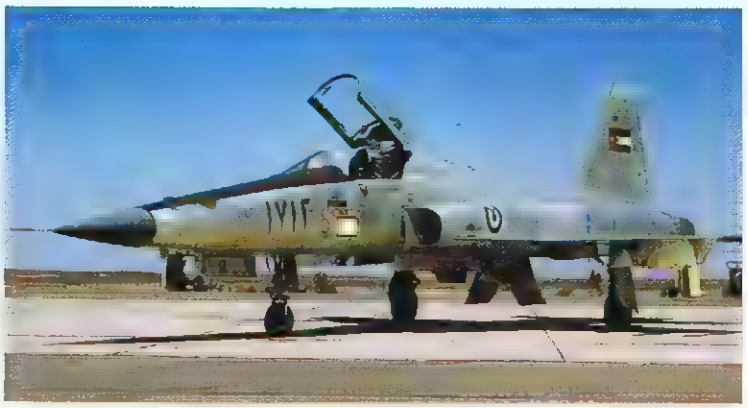
Main picture: Bell Modernised AH-1S Cobras provide the principal counter to any armoured thrust into the country, equipped with TOW missiles. Jordan lost a sizeable proportion of its territory to Israel during the 1967 war, the famous 'West Bank' of the River Jordan.

Above: *A rocket pod stands guard outside an RJAF Mirage squadron building, a suitable warning to potential aggressors. RJAF pilots are some of the best-trained in the Middle East, and morale is high.*

***Above:** Air defence assets are spearheaded by the Dassault-Breguet Mirage F1CJs of No. 25 Squadron, based at Azraq, distinguished by the grey colou scheme. Armed with Matra 550 Magic heat-seeking missiles an Super 530F radar-homing missil the F1CJs were delivered during 1981-82, thanks to Iraqi funding.*

***Left:** A follow-on batch of Mirag was delivered to No. 1 Sqn duri 1982-83, also at Azraq. Wearing desert camouflage, these are Mirage F1EJs, with better air-to-ground capability than their cousins on No. 25. They consequently have more of a du role tasking. This second order also covered 17 single-seat airframes, but no two-seaters.*

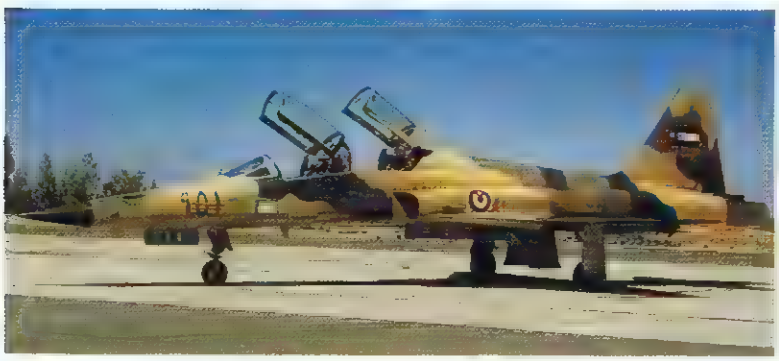
Left: A pair of No. 25's F1CJs cavort for the camera. Nineteen Mirages were supplied in the initial batch, comprising 17 F1CJs and a pair of two-seat F1BJs for conversion training. An important squadron duty is to provide an air defence alert with two aircraft on five-minute readiness.



Right: The Northrop F-5E Tiger II is numerically the most important type in the RJAF, used for both air defence and air-to-ground attacks. This silver example serves with No. 17 Sqn at Prince Hassan AB.

Right: No. 9 Sqn also flies the F-5E from Prince Hassan AB, this example wearing the more common three-tone desert camouflage. Air defence capability comes in the shape of wingtip Sidewinders.

Below: Twelve F-5F two-seaters were supplied with the 61 F-5Es to handle conversion and continuation training. This is a No. 9 Sqn aircraft: No. 17 is the main conversion unit.



Right: RJAF aircraft wear no badges, but their squadron buildings do, as evidenced by the F-5 crew-room. The first digit(s) of the aircraft code denotes the squadron.

Below: No. 9 Sqn F-5Es display the wingtip AIM-9 missiles. AIM-9J, -9N and -9P versions are in use.

Royal Jordanian Air Force

Cessna T-37Bs of No. 11 Squadron dis
the two colour schemes worn by the fl
The silver aircraft are from the origina
batch, while the white aircraft were la
deliveries from the USAF.

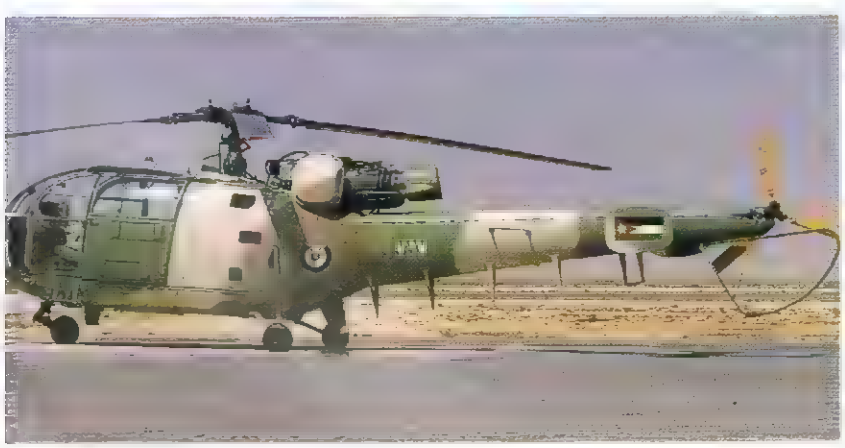
Above and right: Training Command of the RJAF is located at the King Hussein Air College at Mafraq, where BAe (Scottish Aviation) Bulldogs provide candidate screening and primary training duties. Five Bulldog Mk 125s were initially supplied to the Royal Jordanian Air Academy at Amman, joined later by eight more. These were transferred to Mafraq in 1978, and the 12 survivors were joined by nine more Mk 125As. These now form No. 2 Squadron. The syllabus begins with a 10-sortie screening and grading course, which by all accounts is very tough. The successful candidates then move on to about 70 hours' primary tuition, before passing on to basic courses on the T-37 or CASA C-101. Those headed for transport duties are also given multi-engine training on CASA 212s loaned from the operational unit.

Below: Future rotary-wing pilots train on the McDonnell Douglas 500D, eight of which serve with No. 5 Squadron, part of the Air College at Mafraq. One hundred and ten hours of instruction is given, which qualifies the pupils for co-pilot service. Only after 500 hours is the pupil allowed to command operationally.

Right: Only a single Aérospa
SA 316B Alouette III is left in
service with No. 8 Squadron
Amman, although it may now
serve with No. 7 Sqn. The
remainder of the fleet was so
Austria. Other helicopters in
service are the newly-deliver
Sikorsky S-70A and Aérospa
AS 332M Super Puma, both o
which provide useful assault
support for the ground forces
based at Amman is the Jorda
Royal Flight, which operates
of Gulfstream IIIs and a sing
Lockheed TriStar 500 in civil
markings.

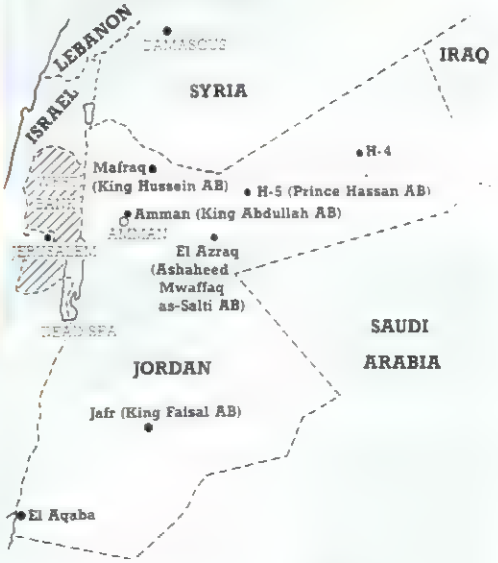
Below: About 15 Cessna T-37Bs serve No. 11 Squadron of the Air College for basic training. These will shortly retire as the CASA C-101CC Aviojet is now in service for this task.

Right: T-37s have served for many years in the basic training role. Graduates from the syllabus aimed for fast-jet flying go to No. 6 Sqn for advanced training, this unit based at Mafraq with F-5A/Bs.



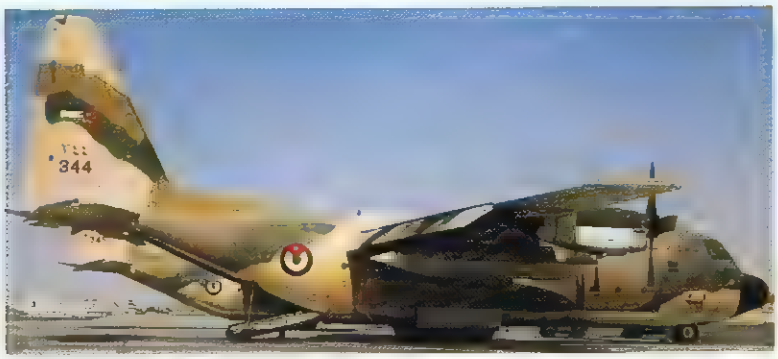
*Above: Twenty-four Modernised **AH-1S** attack helicopters serve with Nos 10 and 12 Squadrons at Amman. Although they have the latest shielded exhausts, they do not have infra-red countermeasures turrets.*

Order of Battle



*Above and left: Light transport is provided by the **CASA 212 Aviocars** of **No. 3 Sqn** at Amman, with an additional reconnaissance tasking performed by one suitably-modified aircraft. The fixed-wing fleet is jokingly referred to as 'Guts Air Line'.*

Squadron	Aircraft	Base
No. 1 Squadron	Dassault-Breguet Mirage F1EJ	El Azraq
No. 2 Squadron	BAe Bulldog Mk 125/Mk 125A	Mafraq
No. 3 Squadron	Lockheed C-130B/H, CASA 212A/AV	Amman
No. 5 Squadron	McDonnell Douglas 500D	Mafraq
No. 6 Squadron	Northrop F-5A/B	Mafraq
No. 7 Squadron	Sikorsky S.76A/B, Aérospatiale AS 332M	Amman
No. 8 Squadron	SA 316B Alouette III, Sikorsky S-70A	Amman
No. 9 Squadron	Northrop F-5E/F Tiger II	Prince Hassan
No. 10 Squadron	Bell Modernised AH-1S Cobra	Amman
No. 11 Squadron	Cessna T-37B, CASA C-101CC Aviojet	Mafraq
No. 12 Squadron	Bell Modernised AH-1S Cobra	Amman
No. 17 Squadron	Northrop F-5E/F Tiger II	Prince Hassan
No. 25 Squadron	Dassault-Breguet Mirage F1CJ/BJ	El Azraq



Above: Six Lockheed Hercules (two C-130B and four C-130H) provide the backbone of the 'Guts Air Line' transport fleet of No. 3 Sqn. These regularly fly international missions.

Below: The S-76A is the main helicopter type in service, flying with No. 7 Sqn on general transport duties. Eighteen were delivered in 1980-82 to the base at Amman.

Above: Two of No. 7 Squadron's Sikorsky S-76A transport helicopters fly in this white scheme for support of Red Crescent activities.

Below: A handful of F-104A/B Starfighters survive as airfield decoys at H-5/Prince Hassan A These previously flew air defen missions with No. 9 Sqn.

'Fitter' Family

The original swept-wing 'Fitter' was typical of the early supersonic jet-powered ground attack fighters, and is now obsolescent. Though pleasant enough to fly, it was severely hampered by inadequate range and payload. The addition of variable-geometry wings and new avionics transformed the machine into an aircraft that is still an effective strike machine.

Below left: An East German 'Fitter-K' takes of About 45 of these aircraft serve with Jagdbombergeschwader 77 'Gerhard Leberecl von Blucher' and with Marinefliegergeschwad 28 'Paul Wieczorek', both based at Laage, nea Rostock.

An academic analysis of the Sukhoi Su-7 suggests that it is a very big and powerful aircraft which can accomplish very little. It has extremely limited endurance and combat radius, and lacks almost all the weapons and avionics considered necessary today to fly a tactical attack mission.

But academic appreciations can give only one side of the picture. The Su-7 pilot could not fail to love his aircraft's handling qualities. He could not fail to be impressed by the devastating power of its 30-mm guns – the muzzle horsepower being roughly three times that of an Aden or DEFA gun of the same calibre. And he could not fail to appreciate the Su-7's unbreakable strength. He could, for example, leap up from the ground and do pull-ups *on the end* of the long nose pitot boom.

These good qualities were unknown to Western analysts when, at the 1967 Aviation Day flying display at Moscow Domodyedovo airport, an Su-7 appeared with the outer wings arranged to pivot. It was obviously not a production aircraft, and Western analysts tended to dismiss it as of no military importance. Taking its cue from these professional assessments even the ultra-cautious *Jane's All The World's Aircraft* recorded, "With newer types already in production it seems unlikely that the variable-geometry Su-7 will become first-line equipment." How wrong this assessment was can be seen from the fact that almost 20 years later the variable-geometry Su-7, designated Su-17 in Soviet service, still outnumbered all other Soviet tactical attack aircraft!

The story of these somewhat misunderstood aircraft began when, in 1948, the pioneer of Soviet axial turbojets, Arkhip M. Lyul'ka, began the detailed design of an outstanding new engine to power future supersonic aircraft. Designated AL-7 by his engine KB (experimental construction bureau) and TRD-31 by the VVS (Soviet air force), this engine was notable in that the blades in the first of the eight stages of its compressor were designed to operate with their outer portions in a supersonic airflow.

The AL-7 first ran in 1952, but during development a 'zero stage' (an extra stage of blading in front of the existing compressor) was added, together with a row of variable-incidence stator vanes between this and the original first stage. The nine-stage engine was qualified for service use at a dry rating of 14,330 lb. In 1956 the AL-7F was cleared for production with a large afterburner and variable nozzle, the maximum ratings being 14,250 lb dry and 19,840 lb with maximum afterburner.

This fine engine, noted for its toughness and ability to ingest foreign objects without apparent harm, was marred only by a tendency towards smokiness, which can be a drawback in tactical aircraft operating at low level. The AL-7F was to provide power for a wide range of Soviet aircraft, including two closely related families designed by the OKB (experimental construction bure Pavel O. Sukhoi, one group with a delta wir the other with an acutely swept wing, both lies having the same rear fuselage and tail deltas were given designations in the 'T' (*t nyi;* triangular) series, while the swep machines were given 'S' designations, from *vidnyi* (arrow-head). The latter got into t first.

Pilot team

The Sukhoi OKB had not been reopene long and had to hire a test pilot, the choice on A. G. Kochyetkov of the Lavochkin OI start the flight test programme with the S- September 1955. Sukhoi quickly built powerful team of test pilots, which include dimir Ilyushin, son of the famous Soviet 'C Constructor'. He was later to become ch pilot and deputy head of the bureau, but the senior man was V. N. Mikhailin, and h the first flight on 26 May 1956 of the T-3, t delta prototype to be built.

Today it seems obvious that, after pro testing, it was discovered that the delta wa ginally faster, especially at high altitudes, in some conditions it had a higher rate of contrast, the swept-wing aircraft had a shorter field-length, handled better at low and had a lower gust response; in other w gave the pilot a smoother ride in rough a

Right: A handful of Su-7 'Fitter-As' of various sub-types remain in service in Czechoslovakia, being used mainly as hacks and target tugs by the operational 'Fitter-K' regiments at Prerov and Namest. This aircraft is an Su-7BKL.

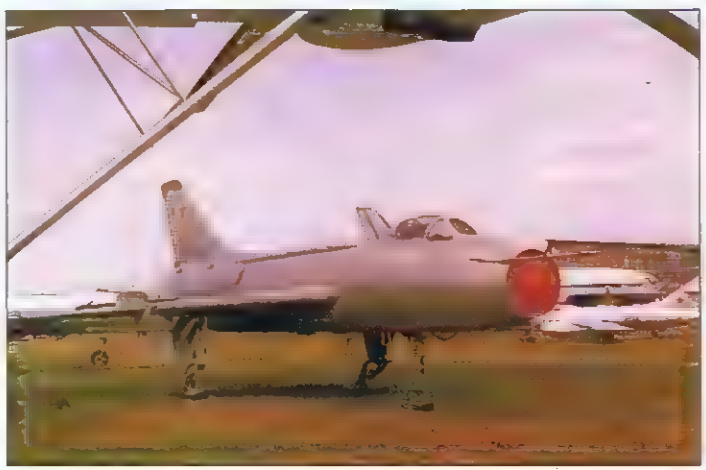
Below: The Sukhoi S-2 was the first true 'Fitter', the earlier S-1 being designed as a fighter with a primary air-to-air role. Its pitot probe was mounted centrally on the pitot type intake.

After further testing the decision was taken to develop the deltas as missile-armed interceptors, operating from long paved runways, and the swept-wing aircraft as 'frontal fighters'. Sukhoi once said the S-1 was the prototype of "the fighter to shoot down the F-100", but air combat was to play a progressively smaller part in the service life of these aircraft – partly because of the existence of the smaller and marginally more agile MiG-21. The secondary role of ground-attack gradually became dominant, leading to minor redesign.

Via the S-2 and S-22 production prototypes, about 20 of which were built in 1958-59, a small batch of fighters was delivered for service with the VVS FA (Frontal Aviation) with the service designation Su-7. Full production of the Su-7B began in 1960. The losing rivals were generally similar aircraft, the I-3U and I-75F, from the A. I. Mikoyan bureau.

Like these rivals the Su-7B had a shapely wing with a wing profile in the symmetric SR-3 series, with a leading-edge sweep angle set at the very sharp level of 62°. Thickness/chord ratio was 5.7 per cent at the root, quite a high value for an aircraft in the Mach 2 class, thinned down to 4.7 per cent at the tip.

A lot of the aerodynamics and structure stemmed from the original Su-17, which was left unfinished when Stalin closed the OKB in 1949, dismissing the staff. The two spars had plate webs with lightening holes, heavy machined skins



This experimental Su-7BM, now in the Air Force Museum at Monino, had an unusual ski-type undercarriage for operation from snow or from very soft strips.

The second S-22 prototype is shown with a full load of S-3K rockets. The S-22 pre-production batch closely resembled the original S-2 prototype.

being screwed on top to complete the main box. Inboard, an extra spar joined the other two at right-angles to the fuselage, the outer junction providing the attachment for the main landing gear. At the root this transverse spar provided the main attachment for the wing, being bolted to a double frame in the fuselage. Secondary spars were attached to two other frames. There was no way the spars could pass through the fuselage because the wing was in the mid-position and the fuselage was full of fuel, with a large air duct down the centre.

The leading edge was 'hard'; in other words, it neither drooped nor contained slats nor any other movable surface. Inside the outboard leading edge were the electro-hydraulic power units driving the large outboard ailerons, Sukhoi having been surprised at the inability of North American Aviation to fit such ailerons to the F-100 without running into wing twist problems.

Inboard of the ailerons were typically impressive track-mounted slotted flaps, somewhat similar to the Fowler flap but forming the entire rear part of the wing without any fixed structure above. In the S-22 the wing was improved by making the inboard flap section rectangular and at right-angles to the fuselage. This had the effect of progressively increasing the chord of the inboard wing towards the root, which in a way improved the area ruling at the wing/fuselage junction, reducing interference and drag.

The uncluttered basic wing was completed, as the result of prolonged flight testing, by an unusual arrangement of fences. It had been found from the start that with such heavily loaded and highly swept wings the spanwise flow problems were considerable, especially at high angles of attack. After trying other schemes the Su-7 family went into production with a boundary-layer fence at 65 per cent span, in line with the junction between the flaps and aileron. This fence was about 6 inches deep and extended all the way round the leading edge and back along the underside of the wing. The second fence had a depth of about four inches and enclosed the whole wingtip to the trailing edge, above and below.

Moving centrebody

The fuselage was of circular section throughout. The nose was formed by the sharp-edged air inlet, with a large centrebody cone which in the production Su-7B housed the SRD-5 radar. The centrebody was arranged to translate – move forward for high-Mach flight and retract to the rear for lower speeds – and it was used as the structural base for the radar's oscillating antenna dish only, the main radar racks being to the rear in the fixed centrebody downstream.

The air inlet ducts were split to pass on either side of the cockpit, with a depth of about 4ft and width of 1ft along each side of the forward fuselage. Behind the cockpit the ducts came together again to pass as a plain tube through the centre of the fuel cells and thence straight into the compressor inlet of the engine.

The AL-7 family of engines was one of the largest ever fitted to fighters, and they dictated the diameter of the rear fuselage. As is often the case with supersonic aircraft the diameter of the afterburner nozzle was greater than that of the intake in the nose, even after the nose had later been redesigned with reduced taper to give a larger inlet handling a greater airflow. With the large afterburner in operation the heat output was so great that a hurricane of cooling air had to be provided between the engine and the liner of the rear fuselage. This required six ram inlets, standing proud of the skin. In virtually every aircraft of the Su-7 family hot bleed air would blast out of a blow-off exit on each side of the fuselage during engine starting; these large grilled apertures were often outlined in red. In all production aircraft the entire rear fuselage could be disconnected at a double frame about 1ft behind the trailing edge of the fixed part of the wing (i.e. leading edge of the flaps). When the rear fuselage is in position the engine and afterburner have additional support from the fuselage rails. Fuel capacity was typically 646.7 Imp gal (2,940 litres), in self-sealing cells in the wings and fuselage. In full afterburner at low level this gave a flight duration of about eight minutes, and inadequate fuel capacity was a basic problem with all early aircraft of this family. At a very early stage, possibly even including the original S-1 and certainly including the S-2 prototypes, provision was made for drop tanks to be carried side-by-side on two fuselage pylons. These tanks are normally of 122-Imp gal (600-litre) size.

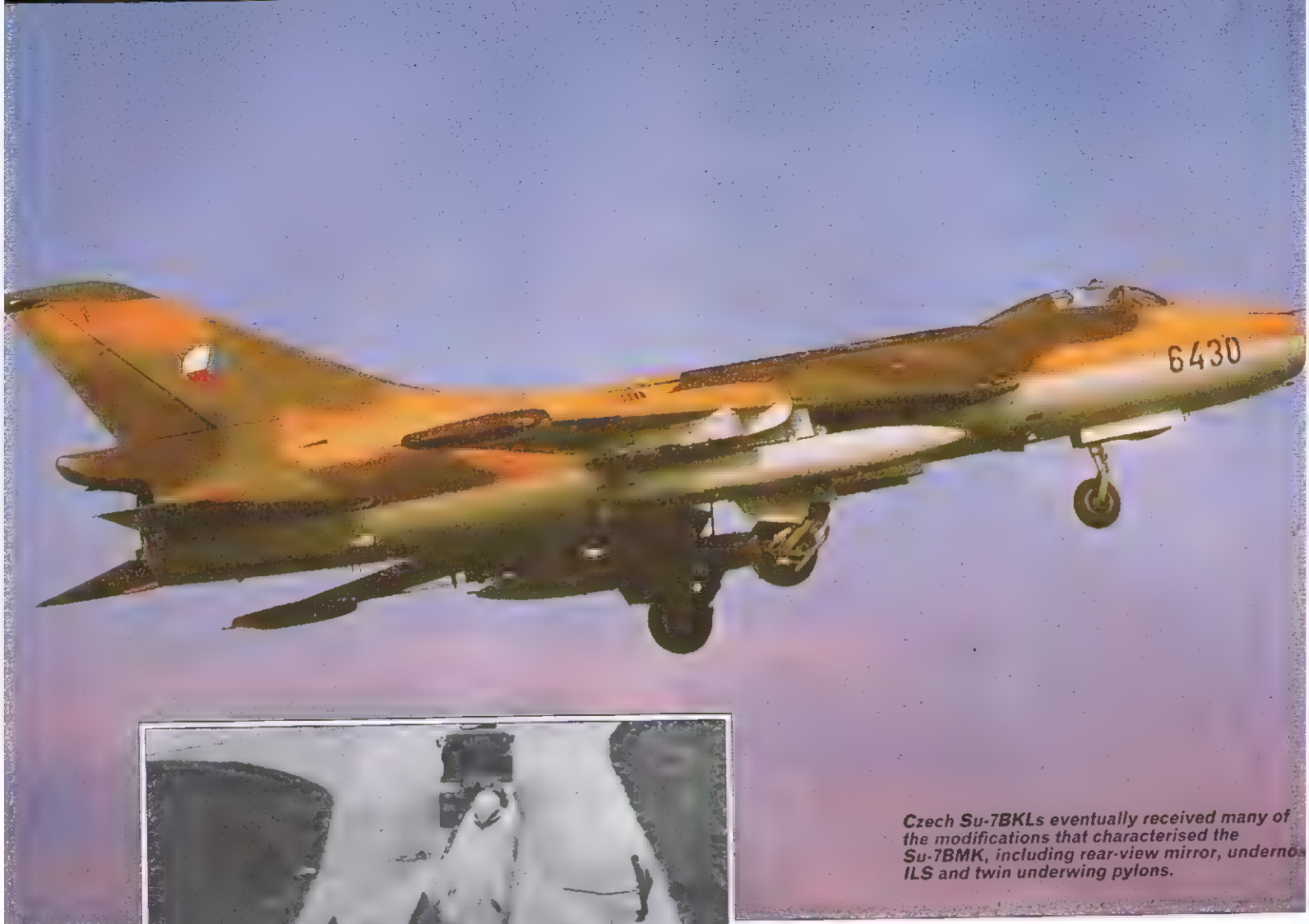
All flight controls were naturally made fully powered, with electrical control but mechanical signalling. The ailerons have been mentioned, and the rudder was again a plain surface with neither balance nor tabs. The horizontal tail was positioned just below the mid-point of the rear fuselage, and was truly horizontal. Very early in the programme, about January 1956, the horizontal tail was made a one-piece powered 'slab' on each side, with a streamlined tubular mass projecting about 3ft ahead of each tip to damp out any tendency to flutter.

Airflow

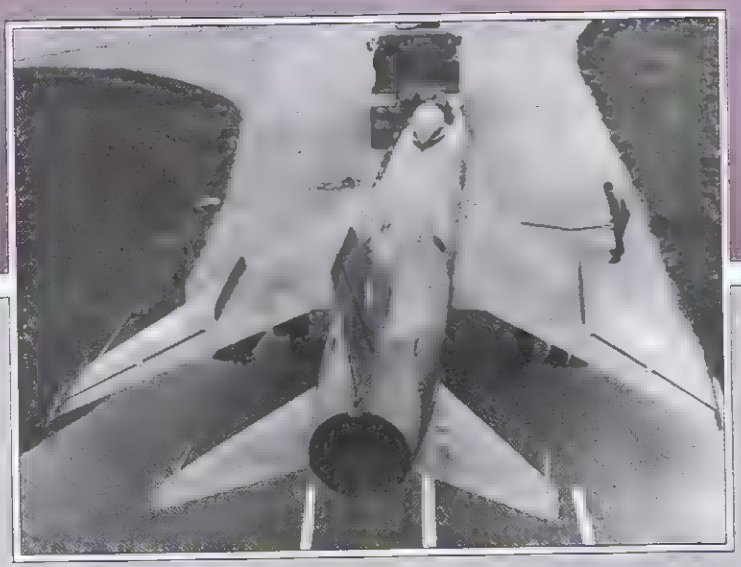
The S-22 series of prototypes introduced the ARZ-1 q-feel system to make tailplane deflection responsive to free-stream dynamic pressure, to avoid overstressing the aircraft at low altitudes. The S-22 series also had a superimposed pair of suck-in air inlet auxiliary doors in each side of the nose to admit the required airflow on take-off and during full-throttle flight at low airspeeds. At some point in development the arrangement of airbrakes, which on the S-1 included a door-type brake under the fuselage, was finally decided as four small door-type brakes mounted around the rear fuselage, one pair giving a wake between the fin and tailplane and the other pair giving wakes under the tailplane. Before production started these brakes were stressed for use at an indicated airspeed of 746 mph (1,200 km/h).

All the early prototypes had the standard SK-1 ejection seat. Based to some degree on the Martin-Baker Mks 3 and 4, this rather heavy seat used pins and safety arms, though as the Sukhoi's cockpit canopy slid to the rear it was not feasible to use an overhead hinged arm as in the early MiG-21s. Even the very first S-1 had a flat bullet-proof windscreen, and a fully pressurised cockpit. The oxygen system was the KKO-2 gaseous bottle-storage type. The heating, pressurisation and air-conditioning plant were grouped under and to the rear of the cockpit, adjacent to the main service and ground-connection panels for the electric, hydraulic, pneumatic and oxygen systems. Beside the canopy on the left side was the venturi for air-driven flight instruments.

Below: A pair of Su-7BKL 'Fitter-As' of the Ceskoslovenske Letectvo get smartly airbo During their early years most WarPac 'Fitte wore an overall silver finish. The Su-7BKL fitted with small metal skids outboard of its mainwheels, which improved rough field capability.



Czech Su-7BKLs eventually received many of the modifications that characterised the Su-7BMK, including rear-view mirror, underno ILS and twin underwing pylons.



Inset left: The wing of the 'Fitter-A' was sharply swept, yet because of its strength suffered few of the problems which beset the similarly radic F-100 Super Sabre.

Left: An Indian 'Fitter-A' lands, with its twin brake chutes fully deployed. Although nominal an Su-7BM, this aircraft has most of the feature of the later, improved Su-7BMK.

All three units of the tricycle landing gear we fitted with single wheels carried on hing levered-suspension arms. In all early members the family the nosewheel could castor but was n positively steerable. The whole gear was e tremely strong, meeting severe requirements f high speed over rough surfaces, and retracted fo wards hydraulically into a bay with two doo under the cockpit floor. The main gears had t wide track of 4 m (13 ft 2 in). Each unit had a wh with multi-disc hydraulic brakes and a high-pr sure tyre, carried on a steel arm pivoted at the fo of the main leg with pivoted links to the sho strut. On retraction the assembly was pulled wards by a jack on the front face of the transve inboard spar to lie entirely within the inner wi As it swung in and up the wheel and door had rotate through 50° to lie flat in the wing, whils push-rod on the front of the leg rotated the a carrying the wheel to tuck the latter up close to leg in the space available (this action shortened main gear by approximately 3 ft). A braking pa chute was housed in a box under the rear fusela in the place occupied by an airbrake in the S-1. canopy was of the ribbon type, 156 inches diameter. The long nose probe at first carr static and dynamic pressure (pitot) heads or

Above: A disillusioned young Afghan air force fighter pilot defected to Pakistan with this 'Fitter-K'. Afghanistan proved to be an important operational testing ground for the later 'Fitters', and resulted in a number of modifications, including the scabbed-on upward-firing chaff/ flare dispensers visible on the rear fuselage of this aircraft. It has been reported that an Afghan 'Fitter-K' was shot down by a MiG-29 while attempting to attack the Presidential palace!

Right: A Czech 'Fitter-K' flies past, with its wings at an intermediate setting. Swing-wing 'Fitter-Ks' serve with fighter-bomber regiments at Prerov and Namest, and SLAR pod equipped 'Fitter-Hs' serve with a tactical reconnaissance Regiment at Kralove. Soviet 'Fitter' Regiments have now been withdrawn from Czechoslovakia.

but in the S-22s pitch and yaw sensing vanes were added. The boom was mounted at the top centre of the nose. The retractable landing light was ahead of the nose-gear bay.

The Su-7IG, also known as the S-22I, provided the stepping-stone to today's 'second generation' aircraft. Even before it entered production the original Su-7 was seen to be a rather limited aircraft, deficient in fuel, weapon load and to some degree manoeuvrability, and certainly in short-field performance. Its wing was to some degree similar to that of the Lightning, but the Soviet machine was a front-line tactical support aircraft. Any attempt to reduce wing sweep, to improve field length and handling, would immediately mean a thinner wing with much thicker skins, necessitating machining the skins from heavy plate, resulting in greater structure weight and much reduced fuel volume.

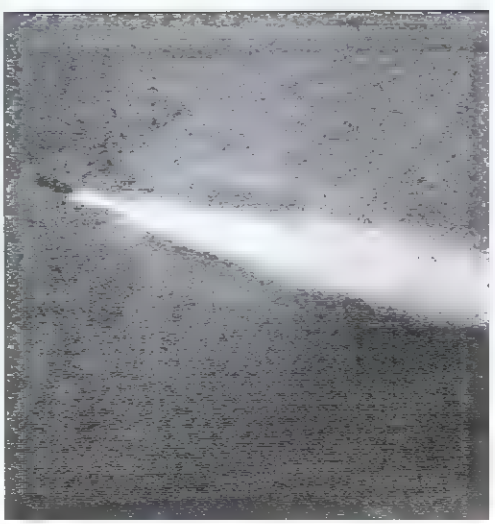
Swing wings

But there was a much more promising answer: variable geometry. By pivoting the wings, so that they could be sharply swept at high speeds and swung forwards to a wide span at low speeds, the aircraft could retain large fuel capacity and have vastly improved lifting capability at low speeds, whilst retaining at least the original high-Mach capability. The structure weight would be slightly increased by the highly stressed bridge and pivots joining the wings, together with their actuation mechanism, but this would still be lighter than a plain, thin, moderately-swept wing. The Soviet Central Aero and Hydrodynamics research institute carried out prolonged tests from 1959, and more work was done by various OKBs. Eventually 'clean sheet of paper' variable sweep was adopted by the Mikoyan and Sukhoi OKBs, for the MiG-23 and Su-24, while a unique partial solution was adopted by the Sukhoi and Tupolev bureaux for the S-22I and Tu-22M.

In these aircraft variable geometry had to be applied to an existing aircraft, with wing-mounted main landing gears. The problems of reconciling rearwards shift of the aerodynamic centre with increasing sweep, together with variation in pressure distribution over the fixed part of the wing and vertical loads on the horizontal tail, could have been almost intractable. In fact, everything fell into place quite well on both the Sukhoi and Tupolev aircraft, and flight testing was very satisfactory. The S-22I made its first flight in the hands of Vladimir Ilyushin on 2 August 1966.

Right: A Czech pilot straps into his Su-22M-4 'Fitter-K' prior to a training mission. External fu tanks considerably extend the 'Fitter's' range.

Below: A Soviet Frontal Aviation Su-17M-4 'Fitter-K' fires an AS-7 'Kerry' guided missile. 'Fitter-K' can carry the full range of Soviet air-t ground ordnance, including tactical nuclear weapons.



Leader of the engineering team was Nikolai G Zyrin.

The 22I retained almost the original inboar wing and main landing gears, though the struc ture had to be restressed because of the variation i outer-wing bending and torsion loads. Ther were many structural modifications, includin the addition of two extruded angle stiffene across the outside of the upper skin, redesign c the trailing edge to be swept back and fitted with flap of constant broad chord, deletion of the slo ted flap outboard of the trailing-edge kink ar addition of internal curved guide rails for the re inboard corner of the pivoting outer-wing bo The outer-wing pivot was placed at the locatic of the former spigot carrying loads from the out pylon. This fitted in perfectly with the requir structural and aerodynamic characteristics, a enabled the outer wing to pivot from 28° sweep 63° (1° more than the original leading edge) wit out the aerodynamic centre moving more thar per cent of mean aerodynamic chord (less than some Western aircraft).

The outer wing, which droops with anhed (variable with sweep) was totally new. Par because of the 63° sweep its taper was greater th before, making the chord much less at the t Whereas the original wing had a broad axial t the new outer wing had a tip aligned with the a flow only at 28°, so that at maximum sweep tip appeared almost pointed. At the inner end trailing edge was equipped with a slotted fl used only at 28° sweep. This reduced the size the slotted aileron, which was also arranged droop when the wings were at 28°.

Power units

As before, the aileron was driven by rods fr a power unit in the leading edge, but instea being well inboard, ahead of the main-gear l the aileron power unit was out near the tip, d ing straight across the wing. This new loca left room further inboard for another hydra power unit driving the full-span slat exten from root to tip of the outer wing and a matically opened at 28° sweep. Because of sweep variation the tip fence had to be elimina but at the root a giant fence was added, c pletely separating the airflows over the inner outer wings and extended all round the profil this fence (and the pivot) was in line with original pylon there was no problem in exten the fence itself downwards into a pylon, th this was not evident on the S-22I.

The yearbook *Jane's All The World's Ai* which is exceedingly cautious and checks o opinion carefully, reported, "There wa reason to expect 'Fitter-B' [the NATO nam form the basis of a production aircraft . . . covery of one or two squadrons in 1972 cam surprise . . . Only after several years did th measure of improvement become apparent combination of a more powerful engine ar variable-geometry wings permitted a doubl ternal load to be lifted from strips little mor half as long as those needed by the Su-7, anc carried about 30 per cent further . . ."

Today more than 3,000 of these variable- descendants of the Su-7 have been built. A mated 1,060 are in service with Frontal Av regiments, with attrition aircraft in storag others with Soviet naval aviation and at l other air forces. Probably no other milita craft has been subjected to such complete re and upgrading over so long a period.

Sukhoi 'Fitter' variants

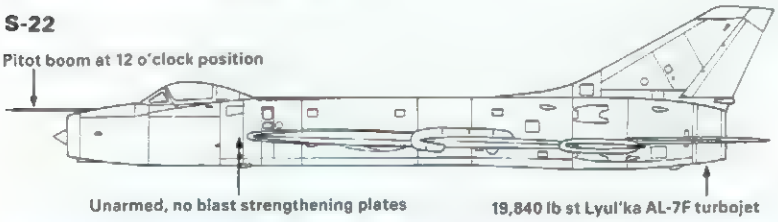
Su-7B 'Fitter-A'

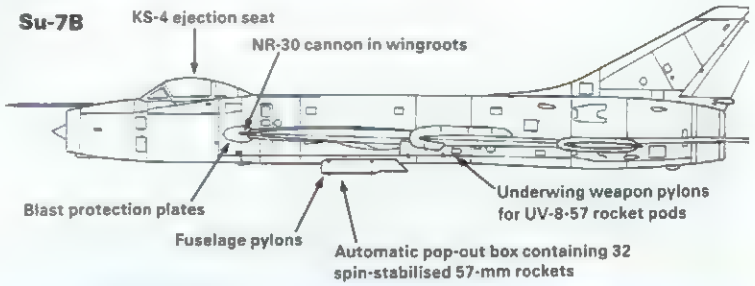
The initial production Su-7 was designated Su-7B (for *Bombardirovschkik*, or 'fighter-bomber'). Only a small number of these aircraft were built, and most were delivered to a single Frontal Aviation regiment during 1960. Externally identifiable by the positioning of the plain air data boom at the top centre (12 o'clock) position of the air intake, the Su-7B was close in build standard to the final S-22 pre-production aircraft. It was powered by an AL-7F engine rated at 19,840 lb st with afterburning, and was armed with a pair of Nudelmann Richter NR-30 cannon in the wing roots, fed with 70 rounds of ammunition from a box located in the tight space between the gun and the wing root.

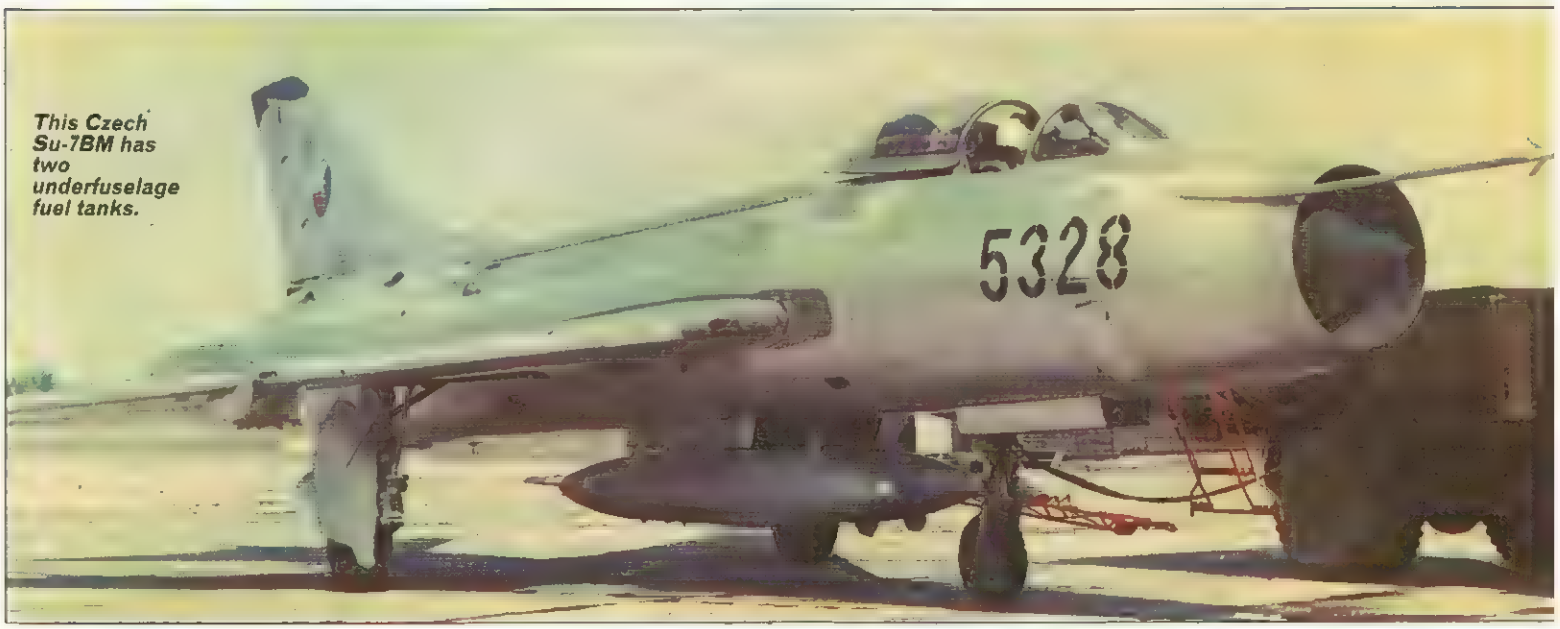
To protect the forward fuselage, strengthened panels were added to the fuselage skin adjacent to the muzzles. A pressurising gas bottle was located ahead of the cannon, with a ventral tubular ram air inlet to purge the gun bay of dangerous gases. The aircraft was also equipped with a box of 32 spin-stabilised 57-mm rockets, this being located in the belly between the two fuselage pylons. It was similar to the Mighty Mouse system fitted to the 'Dogship' F-86D Sabre, extending automatically to allow the missiles to be fired in any desired salvo or sequence before the empty box was automatically retracted. UV-8-57 rocket pods (each containing eight unguided 57-mm rockets) could also be carried on the underwing pylons. The pilot sat on a KS-4 ejection seat, allowing safe escape at heights above 350 feet and at speeds of up to 680 knots.

Above: This Su-7B is unusual in having its pitot probe re-located to the 10 o'clock position.

Left: An Su-7B in the museum at Monino is armed with small rocket pods underwing. This variant was used mainly for operational trials.





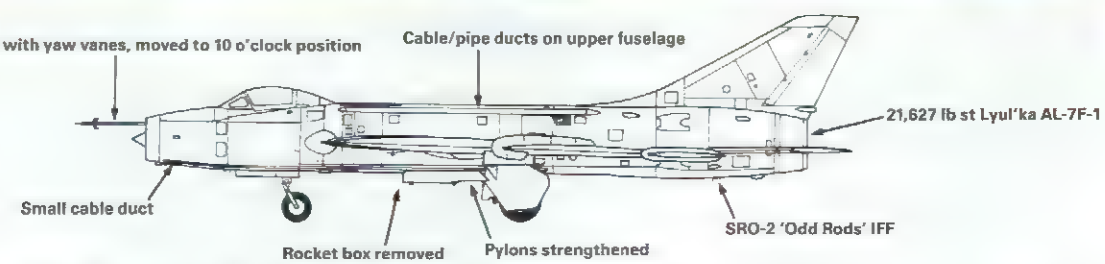


This Czech Su-7BM has two underfuselage fuel tanks.

Su-7BM 'Fitter-A'

The designation Su-7BM (Modified fighter-bomber) was given to the next production variant of the 'Fitter', which began rolling off the line at GAZ-153 at Novosibirsk in 1961. Believed to have introduced the AL-7F-1 engine, rated at 21,627 lb st with afterburning, the new aircraft introduced a host of other improvements. The electrical and fuel systems were considerably refined, with the main accumulator and booster pumps being relocated in the upper fuselage aft of the cockpit. Pipes were added in prominent external ducts along each side of the upper fuselage to the engine. A much smaller cable duct ran along the port lower fuselage from a point level with the front of the nosewheel bay to the engine accessory bay.

The nose probe sprouted pitch and yaw transducers and was moved to the 10 o'clock position on the intake lip, giving the pilot a better view of the runway on landing. The underwing hardpoints of the Su-7B were strengthened to allow the carriage of larger weapons (including the UV-16-57 rocket pod, and bombs of up to 500 kg), but the fuselage rocket box was removed.



The avionics fit was improved with VHF and UHF radio of improved types. Later in their careers many Su-7BMs received SRO-2 'Odd Rods' IFF, with the distinctive uneven tripole antennas located fore and aft under the fuselage. Other standard equipment included the ASp-3VM ranging gunsight, ARK-5 radio compass, MPR-48P marker beacon receiver, RV-2 radio altimeter (with the usual dipole aerial under the inner wings) and the RSIU communications radio.

The Su-7BM was exported to India, Czechoslovakia, Poland and Egypt. Many were later fitted with the rear view mirror fitted to the Su-7BMK as standard, and most Indian Air Force Su-7BMs were fitted with the large twin brake chute housing, fin-top Sirena 2 and extra pair of weapons pylons outboard from the fence that were normally associated with the later Su-7BMK.

Right: A Czech Su-7BM performs at an airshow at Kunovice in 1981. Operationally restricted by its lack of range and payload, the 'Fitter-A' was a popular aerobatic mount.

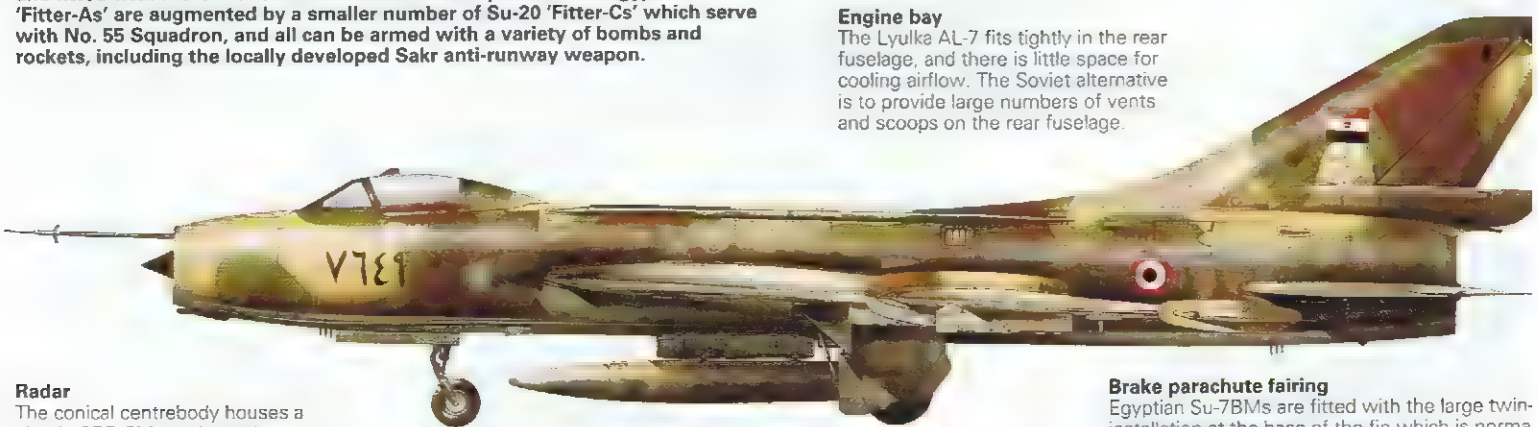
Cockpit
The Su-7BM is fitted with a flat, armoured windscreen and a sliding canopy. Some aircraft h a mirror built into the top of the canopy. Early 'Fitter-As' were fitted with the KS-4 ejection seat many were later fitted with the later KM-1, which could be used at ground level.

Operators
The 'Fitter-A' was widely expo with aircraft going to Afghanis Algeria, India, Iraq, North Kore Syria, Vietnam and South Yem as well as to most of the Wars Pact nations.

Sukhoi Su-7BM 'Fitter-A'

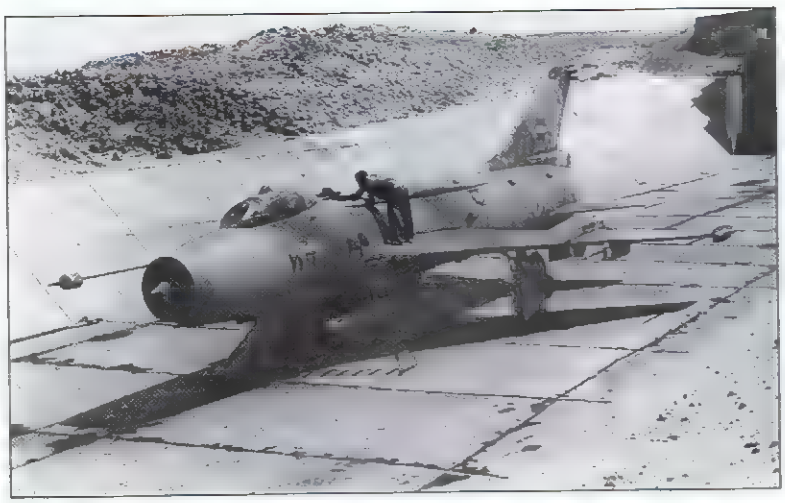
This Su-7BM wears the markings of the Egyptian air force, and serves with a ground attack air brigade at Katamia. The Su-7BM has always been popular with Egyptian pilots, who admire its easy handling and gentle ride at low level, as well as its ability to withstand severe battle damage (except in the engine bay, where even small-calibre rounds can cause problems). Attrition during the October 1973 war with Israel was relatively light, although the force of 'Fitter-As' was intensively used. Following Egypt's split with the Soviet Union, the surviving 'Fitters' were overhauled and upgraded by Western companies, and fitted with more modern avionics and other systems. The Egyptian 'Fitter-As' are augmented by a smaller number of Su-20 'Fitter-Cs' which serve with No. 55 Squadron, and all can be armed with a variety of bombs and rockets, including the locally developed Sakr anti-runway weapon.

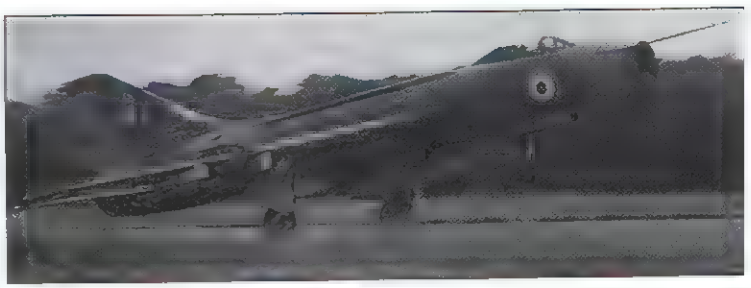
Engine bay
The Lyulka AL-7 fits tightly in the rear fuselage, and there is little space for cooling airflow. The Soviet alternative is to provide large numbers of vents and scoops on the rear fuselage.



Radar
The conical centrebody houses a simple SRD-5M ranging radar, known as 'High Fix' to NATO. The intake centrebody moves in and out to change the intake configuration.

Brake parachute fairing
Egyptian Su-7BMs are fitted with the large twin- installation at the base of the fin which is norma associated with the Su-7BKL and Su-7BMK. This gives the aircraft considerably shorter landing distances.





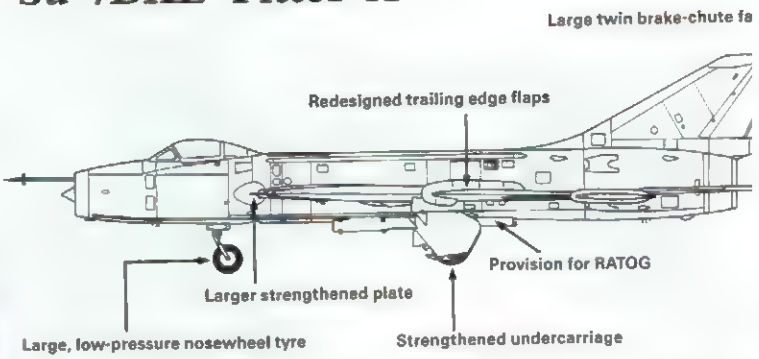
Above: An Indian Su-7BM takes off. India's 'Fitters' equipped six squadrons, and were used in anger in the 1971 war against Pakistan, but all 140 have now been retired. 'Fitter' units won the coveted Arjuna Trophy for gunnery for nine years in succession.

Left: Egypt originally received some 120 'Fitter-As', and almost 60 of the were still in use by 1982. A handful are still believed to be operational, although numbers have dwindled and some have been relegated to decoy, battle damage repair and display duties.

Left: A group of Frontal Aviation Su-7BKL pilots walk away from their aircraft after a large-scale mission.

Below: The Su-7BKL was optimised for use by Frontal Aviation, and to enhance dispersed site capability provision was made for RATOG. The aircraft also featured a large low-pressure nosewheel and auxiliary skids on the mainwheel units.

Su-7BKL 'Fitter-A'



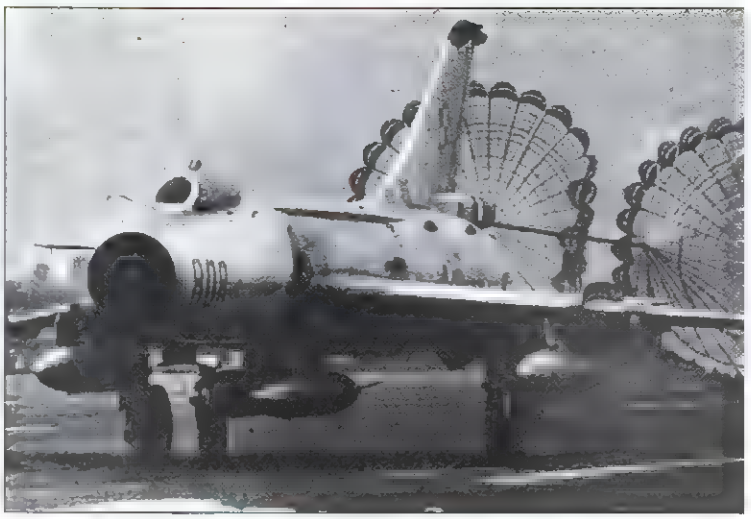
The Su-7BKL as a museum piece, in the huge collection at Monino, near Moscow. Elsewhere, this variant remains in service.

Virtually the standard first-generation series-built Su-7, the BKL introduced several modifications which improve the ability of the aircraft to operate from short unpaved front-line airstrips. Far more than Western air forces, Frontal Aviation has recognised that aircraft parked on a known spot on the Earth's surface might as well be discounted, since they could be destroyed by missiles the night before the war starts.

Accordingly, Frontal Aviation has striven to use only aircraft capable of being dispersed, so the Su-7BKL was given new landing gear and other changes. The nose gear was fitted with a larger tyre inflated to lower pressure. This required minor changes to the leg yoke and bulges on the doors. The main ge were strengthened and fitted with a steel-shod ski carried immediately outboard of the wheel on two shock struts. The ski, or skid, can be retract well clear of the ground for normal operation, but on very soft ground or snow it can be extended to bear almo all the weight of the aircraft, especial speed. The two shock/retraction stru are pivoted to a rearwards extension the pivoted arm carrying the wheel, a this being on the outboard side of the wheel. To house the retracted gear bulges were added under the inboard wing and bay doors. To assist take-of attachments were added for ATO (assisted take-off) rockets. The latter the SPRD-110, and the two attachme are on each side near the bottom of t fuselage/tail break joint double frame assist in short landings the brakes on main wheels were increased in capa and the braking parachute was replac by twin chutes streamed from a compartment at the base of the verti tail. This compartment gave improve chute performance, but required a reduction in size of the rudder and relocation of the tail navigation light a top of the fin above the rudder.

The Su-7BKL's rough field capabili was considerably enhanced by the provision of redesigned flaps, which later re-fitted to many Su-7BMs. As modified, each flap formed a single a sliding out and down to the rear on t aligned with the fore-and-aft axis. Al the outer portion a sharp trailing edg strip was added, giving a slight trailin edge discontinuity. Inboard of the ki and on the underside only, the rear section carried an extra split flap hing to the main flap and depressed to at 50°, the main flap angle being about Most drawings show the inner secti flap perpendicular to the fuselage as separate surface, but this is incorrec

An Su-7BKL blasts into the air, propelled by the thrust of its Lyul'ka AL-7F-1 and a pair of SPRD-110 assisted take-off rockets. The Su-7BKL introduced the large tail fairing housing twin brake parachutes.



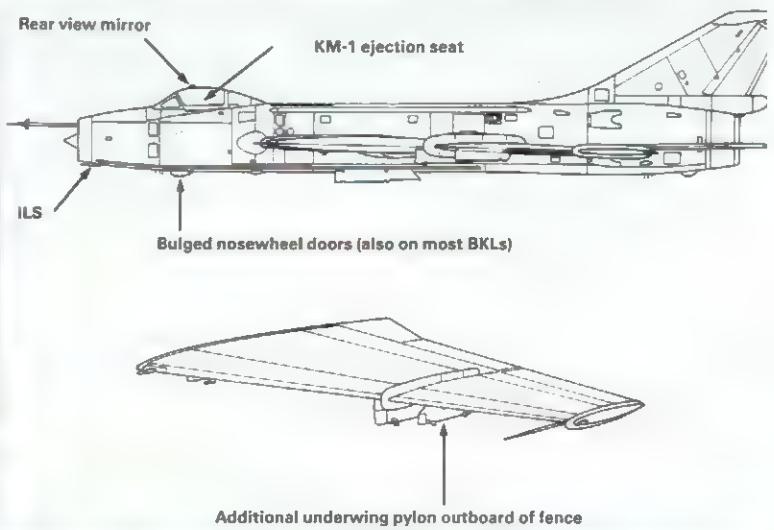
A Polish Su-7 lands, streaming twin ribbon-type brake chutes. Poland was a major operator of the Su-7 'Fitter-A'. This Su-7BKL is fitted with t rear view mirror usually associated with the Su-7BMK.

Su-7BMK 'Fitter-A'

Certainly the final first-generation production version, the BMK introduced various features which, because they are also seen on many earlier aircraft (probably as retrofits), are difficult to assign to the BMK only. One such improvement is ILS, the standard SP-50 installation having the antennas projecting as a slim aft-facing rod at the top of the fin and as a forward-facing round-ended tube (rather fatter than a broom handle) under the nose. Another addition was a rear-view mirror, faired into a blister at the top of the canopy.

The BMK also standardised on the S-3M radar warning system, which as Sirena 2 had also been fitted to the majority of surviving earlier aircraft. The installation covered the aft hemisphere only, the passive helical antenna being housed in a slim pod very near the top of the fin. Some BMKs may have the Sirena 3, in which the pilot is given not only an audio and flashing-light warning but also a visual CRT (cathode-ray tube) display indicating the threat direction. From 1966 the seat changed to the KM-1 with rocket assistance giving zero/zero capability. This seat, by that time standard on all new-production Soviet fighter and tactical aircraft, also incorporates the NAZ-7 emergency survival kit. The 'first-generation' Su-7s were supplied to the air forces of the Soviet Union, Afghanistar Algeria, Cuba, Czechoslovakia, Egypt, India, Iraq, North Korea, Poland, Romar Syria and Vietnam. At least 600 saw action in wars involving Egypt, India, Ira and Syria, not fewer than 270 being los in action. More than 95 per cent of thes losses were either on the ground or as the result of ground-to-air fire.

Above: This line-up of Polish 'Fitter-As' includes BMKs, BKLs, a BM and a single two-seat Su-7UM 'Moujik'. Closest to the camera is another trainer aircraft, a MiG-15UTI 'Midget'.



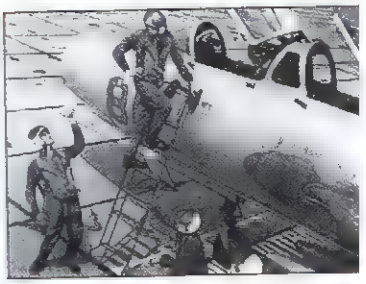
Right: The Su-7BMK was not well equipped for night flying, and had no blind bombing capability. The improvements introduced on the Su-7BMK (KM-1 ejection seat, ILS, rear view mirror, S-3M RWR, etc) were retrofitted to many earlier variants.

Su-7U 'Moujik'

In common with Soviet practice, a two-pilot dual control version was developed, though with a timescale some years later than the single-seater. The Su-7U was first seen in the 1967 Aviation Day display at Domodyedovo. In general this initial trainer version was based on the airframe of the Su-7BM, but with the fuselage lengthened by 300 mm and a second (instructor) cockpit inserted behind the first in the extra bay in the space (previously occupied by avionics and fuel-system components) immediately ahead of the rejoining of the air inlet ducts.

Both cockpits have their own canopy, hinged at the rear and opening upwards. Between the canopies is a large fixed portion providing the hinge for the front canopy and incorporating side windows to give the instructor a limited direct view diagonally ahead. At low speeds (up to 373 mph) the instructor can open a large periscope. This forward viewing system is normally controlled by the landing gear selection. On take-off the instructor looks ahead through diagonally inclined lower and upper mirrors. When the gear is selected up the lower mirror, inside the cockpit, swings down to lie vertically above the instrument panel directly in front of the instructor (who has no direct forward view anyway), while the upper, external, mirror folds forward and down into its recess in the top of the canopy. The rear canopy is blended into a prominent dorsal spine which continues along the top of the fuselage to the fin.

Normally, full armament is retained, though external pylons are generally required for tanks. There is a separate instrument venturi on the left side beneath each canopy, and the radio altimeter antenna is moved from the wing root to a position under the nose immediately ahead of the SRO-2 antenna.



Above: At almost every level, Soviet flying training often followed a set pattern. An essay o the flight to be conducted was followed by a choreographed wal through of the flight, sometimes using models of the aircraft as seen here, followed by the flight itself.

Left: Su-7Us of a Soviet training unit.

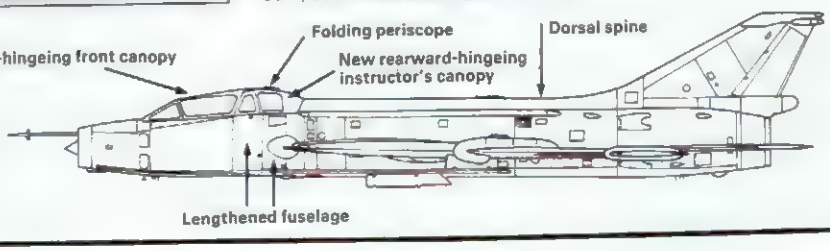
The seats are of the SK type. Extra drag of the canopies and spine results in a slight reduction in flight performance, a of course range and endurance are significantly affected.

Above: The Su-7UM 'Moujik' was based on the Su-7BMK airframe, with the larger brake chute fairing but without a rear view mirror for the front cockpit, and usually without the extra underwing pylon.

Su-7UM 'Moujik'

Built in much greater numbers than the Su-7U, the UM is based on the BMK airframe (no trainer has been seen with BKL features). The UM thus has twin braking parachutes in the long box above the jetpipe, S-3M (Sirena 2) radar warning and KM-1 rocket-assisted seats. Some Su-7 trainers have no radar, which would help to preserve the centre of gravity position. Su-7UM conversion and combat-proficiency trainers were used by most of the air forces equipped with the Su-7, as well as (it is reported) Libya.

Above: An Egyptian 'Moujik' sits outside its hardened aircraft shelter.

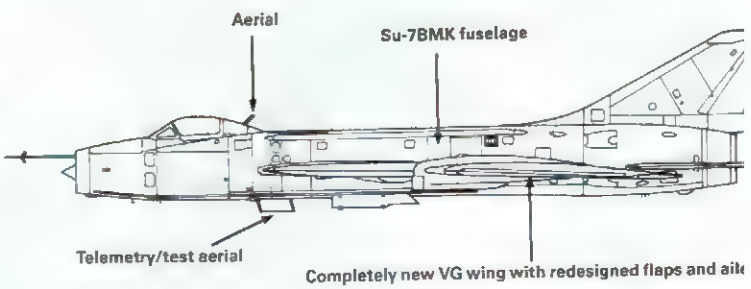


Su-7IG 'Fitter-B'

The first swing-wing 'Fitter' was the Su-7IG (with the OKB designation S-22I), which made its first public appearance at the Soviet Aviation Day display at Domodyedovo in July 1967, alongside a plethora of other prototypes and research aircraft. The silver-painted Sukhoi, wearing bright-red wing and fin leading edges and with red lightning flashes on the fuselage, gave a convincing display in the hands of Ye. Kukushyev, making a short take-off with the wings swept fully forward and then flying a demanding sequence of loops and rolls with the wings swept fully back.

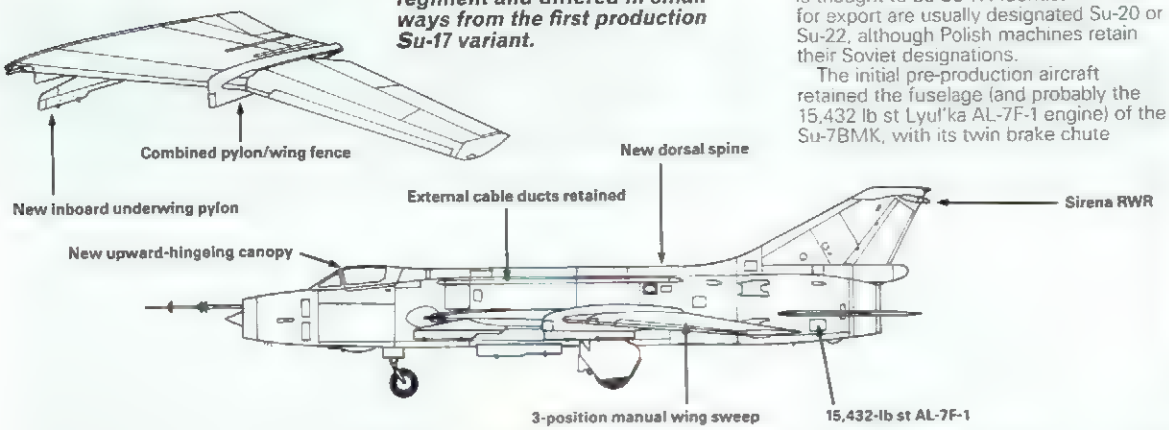
The aircraft was obviously based on the fuselage of a standard Su-7BMK, and was immediately dismissed by Western analysts as a one-off VG research aircraft, 'produced cheaply in order to gain experience with VG techniques'. The experts were misled by the absence of armament and the eye-catching colour scheme, and did not believe that a design as old as the Su-7 could form the basis of a new production aircraft. NATO's Air Standards Co-ordinating Committee did allocate the reporting name 'Fitter-B', however, which was not normally done for one-off research aircraft. In fact the Su-7IG should more properly have been described as the prototype of a new family of Sukhoi fighter-bombers, as soon became apparent. The Su-7IG combined the fuselage of an Su-7BMK with an entirely new variable-geometry wing, with redesigned flaps and ailerons and incorporating greater taper. Aerials for test and telemetry equipment were carried under the forward fuselage and just behind the canopy.

Above: Western experts initially dismissed the Su-7IG as a mere research aircraft and VG testbed, misled by its special colour scheme and lack of armament.



Below: The Su-7IG thunders into the air at Domodyedovo during the Aviation Day show in July 1967, flown by Kukushyev.

The pre-production Su-17 swing-wing 'Fitters' equipped a trials regiment and differed in small ways from the first production Su-17 variant.



Pre-production Su-17 'Fitter-B'

The designations applied to Sukhoi's swing-wing fighter bombers are confusing. All production swing-wing 'Fitters' have the OKB designation S-32, and the Soviet air force designation for all aircraft (including the Su-22M-4 'Fitter-K') is thought to be Su-17. Identical aircraft for export are usually designated Su-20 or Su-22, although Polish machines retain their Soviet designations.

The initial pre-production aircraft retained the fuselage (and probably the 15,432 lb st Lyul'ka AL-7F-1 engine) of the Su-7BMK, with its twin brake chute fairing at the base of the fin, and with Sirena TWR at the top of the fin trailing edge. The Su-7IG three-position manual wing sweep was retained, with 28°, 45° and 62° settings. An upward hinged canopy was also fitted, similar to that used to cover the front cockpit of the Su-7UM, and usually incorporating MDC (Miniature Detonating Cord) triggered before ejection. At the rear this canopy faired into the dorsal spine, curving up at the rear into the fin.

A fence was fitted to the outer part of the fixed wing glove, extending round the leading edge and back across the whole of the upper surface. Integral with this fence was a pylon. Inboard of this was a further fence, extending round the leading edge and back across the wing to about 60 per cent chord. Inboard of this was added another pylon, carrying a store below and ahead of the wing leading edge. A second fence was added between the fence/pylon and the fuselage. Sufficient pre-production Su-17s were produced to equip two trials squadrons.

Su-17 'Fitter-C'

The first major production version, dating from late 1969 and in service in 1970-71, introduced several major changes. The most obvious alteration was that the forward fuselage again derived from that of the UM trainer, being lengthened immediately aft of the cockpit by 9 in. Another not obvious change is that the vertical tail was redesigned. This was done to counter the increased length ahead of the wing, and the new tail has a three-spar fin which, with the rudder, has greater height. The longer fuselage and dorsal spine together increased internal fuel capacity from 830 to 1,000 Imp gal. This additional capacity was certainly needed, as the engine, in this and almost all subsequent versions for Soviet service, was the Lyul'ka AL-21F-3 rated at 17,196 lb dry and 24,690 lb with maximum afterburner. This fully compensated for the considerably increased weights of the variable-geometry versions, especially with pylons loaded. The main production Su-17 was fitted with nine pylons, one on the centreline, two tandem pairs on the fuselage and the four under the fixed wing. Maximum external load was set at 8,820 lb (some Western sources cautiously say "more than 7,000 lb"). The stores are far more varied than in the case of the Su-7 family, including the GSh-23L twin-barrel cannon pod and the large centreline multi-sensor reconnaissance pod housing four (forward and oblique) optical cameras, an IR (infra-red) linescan and side-looking dielectric panels covering the receiver antennas for a passive Elint (electronic intelligence) system.

Weapon delivery accuracy was enhanced by additional avionics, including augmented high-precision pitch/yaw vanes on the nose air-data boom, a second pitot boom on the upper left side of the nose and an AOA (angle of attack) transmitter vane on the left side of the nose just ahead of the suck-in auxiliary inlet doors. The AOA vane is a great help in making perfect landings, and in any case Polish sources claim that the Su-17 lands 62 mph slower than the Su-7BMK. This reduces the braking-parachute requirement, and instead of two ribbon canopies the Su-17 has a single braking parachute of the broad cruciform type with four peripheral slits. This packs into a smaller tube above the jetpipe, with a symmetrical clamshell-cone door which, like the totally different doors on the Su-7, splits into left/right halves to open.

The eight weapons pylons fitted to 'Fitter-C' can clearly be seen in this photo of an early Su-17.

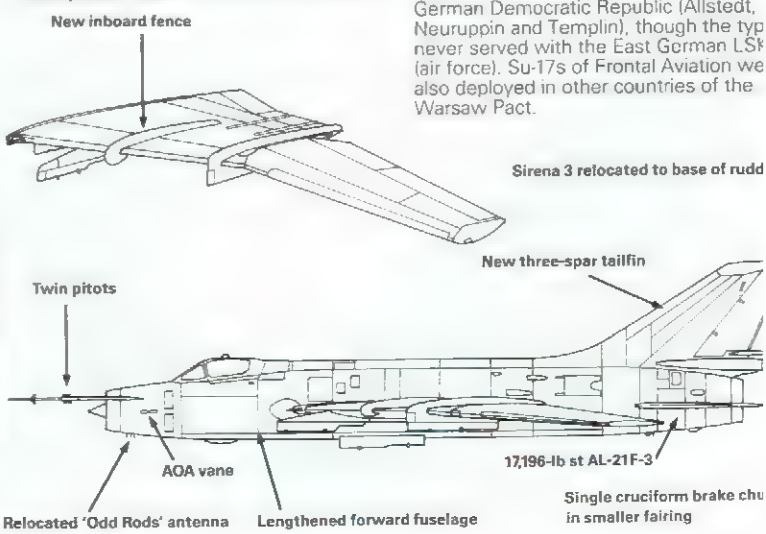
The presence of the dorsal spine rendered the prominent pipe fairings along each side of the fuselage unnecessary, and these were removed. So too were the prominent compressor blow-off apertures on each side of the fuselage which had been such a noisy hazard during engine starting. The ram-air cooling inlets around the afterburner were completely repositioned, and this in turn enabled the four airbrakes to be moved forward three frames and considerably enlarged.

As noted, the avionics fit was upgraded, quite apart from the improved air-data sensors. As in the Su-7BMK the radar was the I-band SRD-5M, linked to the ASP-5ND fire-control system which included the computing optical sight used for guns, rockets and, with depressed reticle, dropped stores. Rather surprisingly, the aft-facing antenna for the S-3M radar warning system (which by this time was the Sirena 3) was moved from near the top of the fin to immediately above the drag-chute tube, necessitating a further reduction in the size of the rudder, which in all current versions has a kinked bottom edge. This system was at last augmented by adding the usual small white disc flat-spiral antennas in the leading edge of the wing, between the fences, to cover the forward hemisphere. The IFF installation had by this time become the SRO-2M, and while both triple groups of tuned rod antennas remained on the underside of the fuselage the forward group was moved forward to within 18 in of the intake lip. This in turn required repositioning the forward rod antenna of the SP-50 ILS Communications radio, for the first time in a Soviet tactical aircraft, included an H set able to receive or transmit over global distances. The equipment was the RSB-70, widely used in strategic aircraft, with a flush antenna under two dielectric panels in the dorsal spine. The VHF and UHF remained the R-831 and RSIU-5, respectively, and an extra was the ARL-S data-link receiver. The usual SOD-57M ATC/SIF (air traffic control selective identification facility) was retained, with small transponder blade antennas on each side below the braking parachute container.

Navaids included the NI-50BM Doppler radar computer (usable in conjunction with the SRD-5M), RSBN-2S short-range navigational receiver, ARK-10 radio compass, MRP-56P beacon receiver and RV-UM radio altimeter. The basic Su-17 was also cleared to launch the air-to-surface missile called AS-7 'Kerry' by NATO, but nothing is known of aircraft-mounted guidance equipment.

The Su-17 series version entered service with Frontal Aviation, and with the Group of Soviet Forces in Germany, in early 1971. By 1972 Su-17s were fully operational from three bases in the German Democratic Republic (Allstedt, Neuruppin and Templin), though the type never served with the East German LSK (air force). Su-17s of Frontal Aviation were also deployed in other countries of the Warsaw Pact.

One of the first operational Su-17 'Fitter-Cs' is seen on approach to a base in East Germany during 1972.



Su-17 'Fitter-C'

he Polish air force, the Polskie Wojska otnicze, was the first WP air force utside the Soviet Union to receive rcraft of the S-32 family. Deliveries took lace in early 1974, and on 22 July of that ear Polish Su-20s were publicly shown uring the PWL's 30th anniversary elebrations. One regiment of 36 has for any years been based at Pila.

Contrary to popular reports, they ppear to be, in all important respects, ncluding avionics, identical to Soviet u-17s. They have always been npainted, and identified by a red four-igit number on the forward fuselage eginning with 42, 62 or 71, though one ircraft carried the number 03. Training as been carried out with guns, UV-16-57 ocket launchers, FAB-100 (220.5-lb) ombs, GSh-23L gun pods (right-hand uselage pylon) and a reconnaissance ack (centreline). The last item differs rom a Soviet pattern in having flash artridges in place of an IR linescan. It as been reported that in at least one ersion the rear section of the pod ouses fuel. Normally external fuel is oused in standard 158-Imp gal drop anks carried on the two fuselage and wo outboard wing pylons. Other stores re carried on standard ejector-release nterface units, such as the RK-54 for ingle or twin stores up to a total of ,205lb, or the tandem triple unit (for example, for six FAB- or PTAB-100) or the special interface rails for AAMs (air-to-air missiles, of the K-13A or R-60 classes (called 'Atoll' and 'Aphid' by NATO). Not seen on training missions, but available for operational use, the AS-7 'Kerry' ASM can be carried on any of the four wing pylons.

Poland's 'Fitter-Cs' are identical to Soviet aircraft, and are perhaps best described as Su-17s, although officially all export VG 'Fitters' are Su-20s or Su-22s.

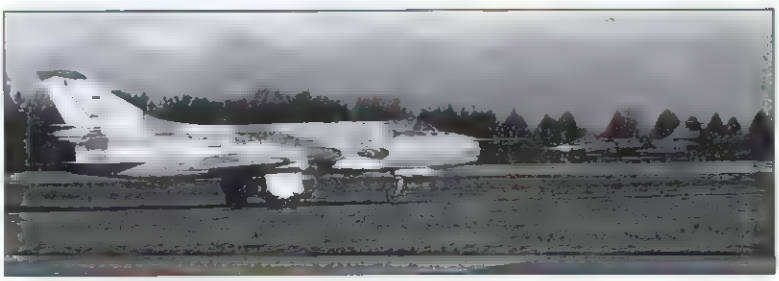
Above: A Polish Su-17 'Fitter-C' lands. Poland's 'Fitter-Cs' were delivered in 1974, and are based at Pila.

Below: Armourers and engineers turn a Polish Su-17 around at Pila. At least 36 are in service.

Su-20 'Fitter-C'

This is the generalised designation for export versions of the Su-17, with Sukhoi designation S-32MK and also with the Soviet designation Su-17MK. The differences between the various Su-20s and Soviet Su-17s are invariably said by Western observers to be confined to removal of certain items of electronics, or their replacement by older equipment. Careful study of photographs does not show any apparent difference in the antennas fitted, and so it is not possible to comment on this, though some export customers for later versions have complained of inadequate avionics, as explained later.

There is also a slight puzzle concerning the gun armament. Many years ago a cutaway drawing was published in Italy showing the 70-round belt of ammunition loaded at the top of the fuselage (of an Su-7BMK) and fed down the curved side of the fuselage to the gun, as in the feed to the single centreline gun of MiG-21s. This was decried as nonsense by other Western analysts, and British cutaways (for example) show the magazine as a light box between the gun and the wing root rib. It is simple to show that 70 rounds could not be accommodated here. But recently several further photographs have become available showing the ammunition tanks being reloaded. Some show a Polish Su-20, and while the ammunition bay door appears to be in the top of the wing root, the belt contains only 20 rounds. Other pictures show a much later Su-22M-4 (described later), again of the Polish air force. Here the belts contain 70 rounds, and are loaded through a large hatch on each side of the spine above the fuselage!



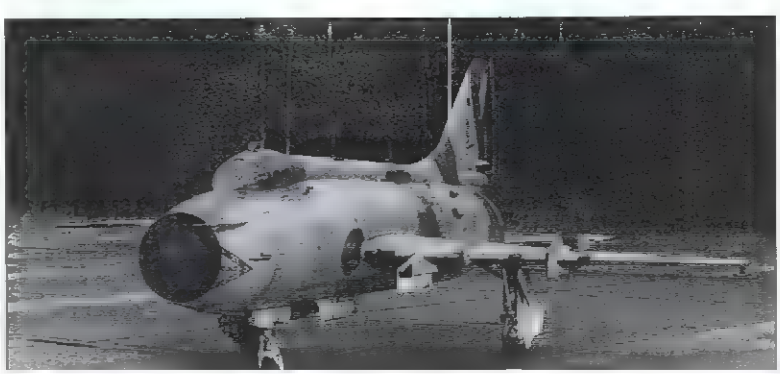
Above: Two ex-Egyptian Su-20 'Fitter-Cs' were delivered to West Germany where they were thoroughly evaluated by Est 61.

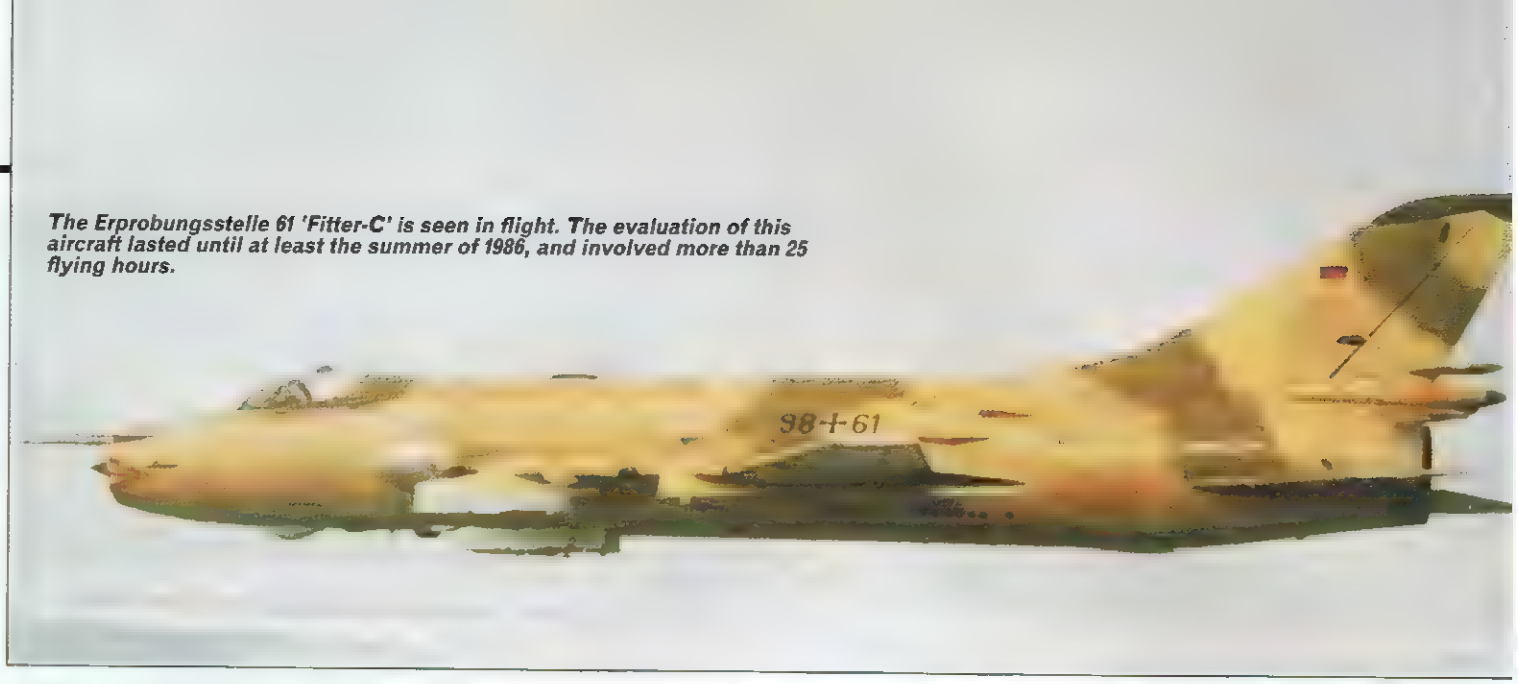
The very first country to receive exported Su-20s was Syria. Sufficient were supplied during 1973 for the type to have become fully operational during the Yom Kippur war, and on Day 8 of that war (16 October 1973) Israeli forces shot down four Su-20s, and had the wreckage to prove it (three near Mount Hermon and one during an attack on Haifa). This was certainly the first time the swing-wing Sukhois had been in action, and over the next 15 years the majority of the Syrian Su-20s were to be lost in action.

Unofficial Western reports have stated that, while a typical export price for an Su-7BMK was about US$1.8 million, a typical 1975 price for an Su-20 was US$2 million. Such figures mean little unless one is given such information as the spares provisioning, support equipment and training included, but they do give an indication of the apparent 'bargain basement' prices of Soviet defence equipment. Other recipients of the Su-20 included Afghanistan, Algeria, Angola, Egypt, Iraq, North Korea and Vietnam. The only other WP operator is the Czech air force, the CL (Ceskoslovenske Letectvo). The number supplied has been estimated at between 40 and 100.

In 1985 two Su-20s were purchased from Egypt by the government of Federal Germany. They were acquired purely for intelligence and evaluation purposes. Dismantled and crated, they were delivered to Erprobungsstelle 61 at Manching. Here one was retained dismantled as a source of spare parts for the other, which was left in desert camouflage but painted with West German national markings, with black code 98+61 on the centre fuselage. Curiously, practically nothing has so far been disclosed, and even the basic unknowns – for example, the size and location of the gun magazines – remain unknown, so far as the world at large is concerned. It has been said that 98+61 flew 25 hours, ending in the summer of 1986, and that no attempt was made to fire the guns or drop or launch external weapons. In fact, as far as the general handling and flight performance are concerned, far more has been disclosed by Egyptian pilots! Several of the latter have waxed lyrical about all the Sukhois, one describing them as "the best low-level tactical aircraft in the world," but with the proviso that, even in the swing-wing versions, endurance is very short, and missions at low level seldom exceed 15 minutes.

Below: Only one of the Luftwaffe 'Fitters' was flown, the other being used for spares.



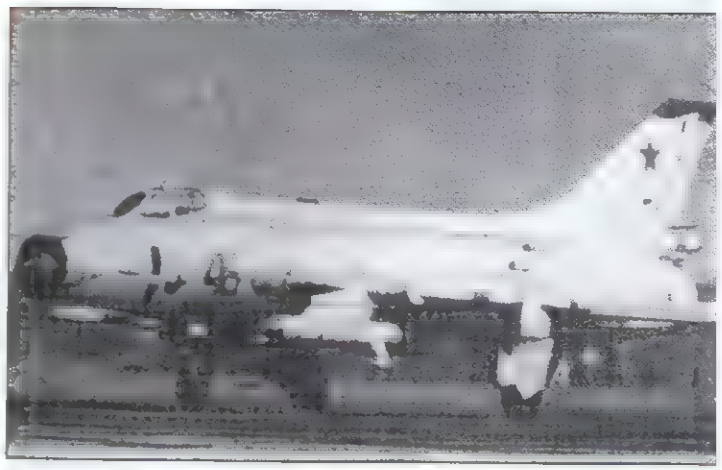


The Erprobungsstelle 61 'Fitter-C' is seen in flight. The evaluation of this aircraft lasted until at least the summer of 1986, and involved more than 25 flying hours.

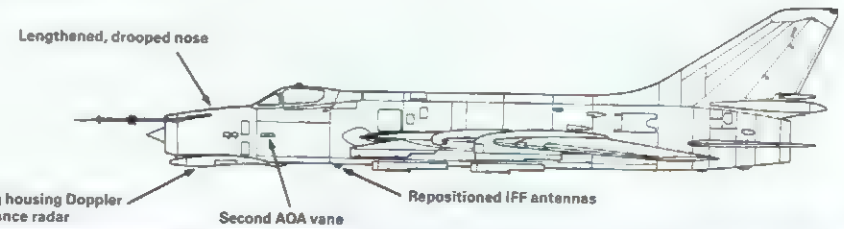
Above: A line-up of Frontal Aviation 'Fitter-Ds'. These aircraft were photographed during the early 1970s, before camouflage was introduced.

accommodate the undernose pod the SRO-2M antenna group was repositioned behind the nose gear.

These additional avionic items obviously enhanced the ability of the Su-17M to fly low-level missions, navigating accurately under the beams of defending hostile radars. At the target the laser would probably reduce circular error with free-fall bombs by a factor of 10, and would also improve results with guns and rockets – it would be logical for target range to be transmitted to the HUD (head-up display) fitted to all Su-17s. It would also be logical for the laser to be used to designate targets for the AS-10 'Karen' ASM, which in one of its most important forms has laser homing. This missile is known to be carried by the Su-17M. Most aircraft of this type in service with Frontal Aviation are camouflaged, with their coloured individual numbers outlined in white. One Su-17M, however, with red number 46, has been seen unpainted in a photograph released in 1986. This photograph was the first seen in the West depicting a Soviet aircraft carrying a large active ECM jammer pod, carried on the left inboard wing pylon.



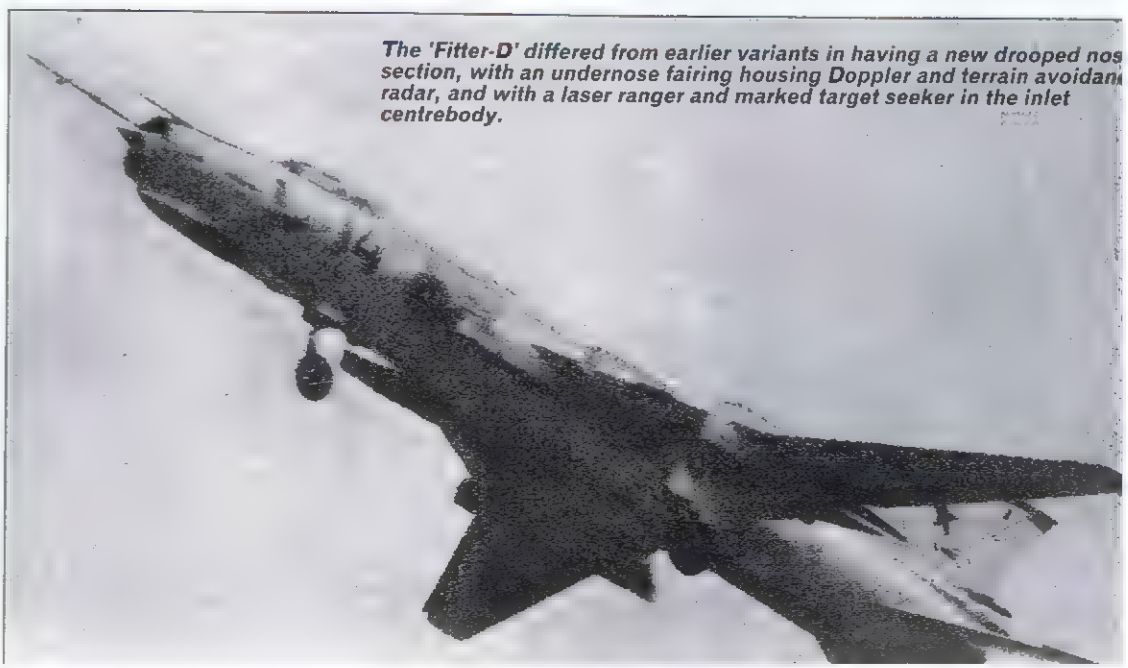
Above: An early Su-17 'Fitter-D' carries an unidentified ECM or targeting pod.



Su-17M 'Fitter-D'

Known to the Sukhoi OKB as the S-32M, this upgraded aircraft entered production in 1974. This introduced a completely redesigned fuselage nose section, ahead of the cockpit. This was lengthened by 15in, and (while keeping the air inlet face vertical) angled downwards 3° so that the tip of the inlet cone was lowered by several inches, the bottom line becoming almost horizontal. This improved pilot view ahead, and the point could be made here that improved view was needed only during missions against surface targets. Whereas in the Su-7 series view ahead on landing was almost non-existent, the variable-geometry aircraft land in a much flatter attitude, the pilot being able to see the runway throughout.

The longer nose of the M aircraft was required in order to accommodate a slim fairing under the nose ahead of the nose-gear bay, housing a forward-looking terrain-avoidance radar and a downward-looking Doppler navigation radar. Inside the inlet centrebody was installed a laser ranger and marked target seeker, looking ahead and slightly downwards through a window in the underside of the cone. About 3 ft to the rear of the AOA vane was added a second sensor looking very like a duplicate AOA transmitter. Not all Su-17Ms have this second device, and its purpose is unknown (though it could of course be a duplicate AOA vane). To

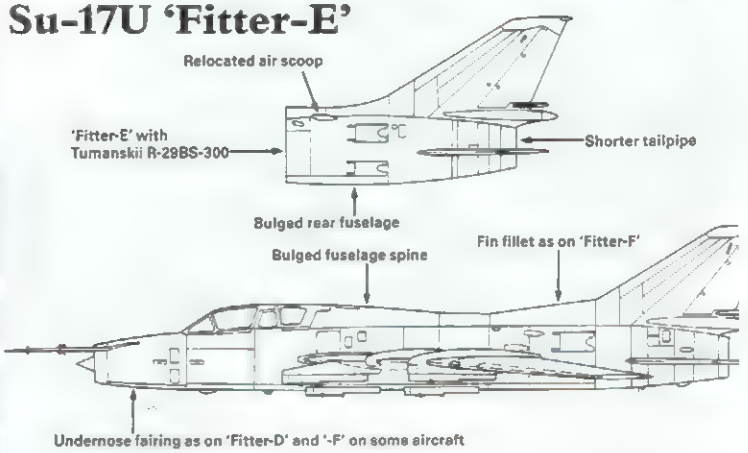


The 'Fitter-D' differed from earlier variants in having a new drooped nos section, with an undernose fairing housing Doppler and terrain avoidan radar, and with a laser ranger and marked target seeker in the inlet centrebody.

Above: An Su-17 'Fitter-D' takes off from an airfield in the Leningrad military district during August 1983. The 'Fitter-D' was a very much more capable aircraft than the 'Fitter-C'.

Below: A Frontal Aviation pilot boards his 'Fitter-D' for a night mission. With its advanced avionics suite, 'Fitter-D' was much more capable than its predecessors.

Su-17U 'Fitter-E'



Pavel O. Sukhoi died in 1975, while the OKB's workload was at an unprecedented level. Part of the effort was concerned with the continued upgrading of the S-32 family. Variants emerged thick and fast and it is impossible to ascertain an exact chronological order. It seems likely that the next prototype to fly was a two-seat trainer, the U-32 or Su-17U, called 'Fitter-E' by NATO. This was based on the fuselage of the Su-17M 'Fitter-F', with the same extended dorsal fin fillet. It incorporated several completely new features that were to become standard on all subsequent versions. The principal change was total redesign of the fuselage as far back as the tail break junction. The length from the inlet lip remained unchanged, but the structure was totally revised, as were the air inlet ducts. The front fuselage was deepened by almost 25 per cent, the bottom line (ahead of the IFF antenna) bulging downwards and the circular inlet being moved about 5 in downwards. The front (pupil) cockpit was moved 8 in forwards, and this, together with the lowered nose, greatly improved forward view, the angle ahead over the nose reaching 15°. This new location of the forward cockpit was to be retained in all future single-seat versions.

On the other hand, whereas the instructor cockpit could have been raised considerably, this was left almost at the original level, requiring the retention of a retractable periscope for forward view. To the rear of the cockpits the spine was made very much deeper and wider. This enabled internal fuel capacity to be increased significantly, except for the bay for 30-mm ammunition. In the cas of the two-seaters the dry bay is retai on both sides, even though the left gu not fitted. The instructor cockpit natur reduces internal fuel slightly, to a total about 1,120 gal.

The deeper forward fuselage eased pressure around the cockpit area for cabin environmental machinery, avion mission sensors and many other item The terrain-avoidance radar was omitt but the Doppler navigation radar was housed inside the fuselage, looking through a flush oval dielectric panel or the centreline. Ahead of this is the flu antenna for the radar altimeter, of a ne pattern. Several other antennas were later to be added under the forward fuselage. Curiously, the centreline retractable landing light was replaced two lights retracting to the left and rig of the front of the nosewheel bay. Th latter was now deep enough to house the complete gear without a bulge, ar only two doors were needed instead the previous four. The laser was retai in the centrebody. So too were all pyl for external stores. Aft of the breakpo double frame there were no changes.

All Su-17Us were powered by the AL-21F-3, and these aircraft have beer seen both camouflaged and unpainted U-32 export versions, believed to be designated Su-22U, have so far been seen only with the R-29BS-300 engin Among recipients are Afghanistan, Algeria, Angola, Iraq, Libya, Peru, Vietnam and North and South Yemen Like the Soviet Su-17U these are all c 'Fitter-E' by NATO.

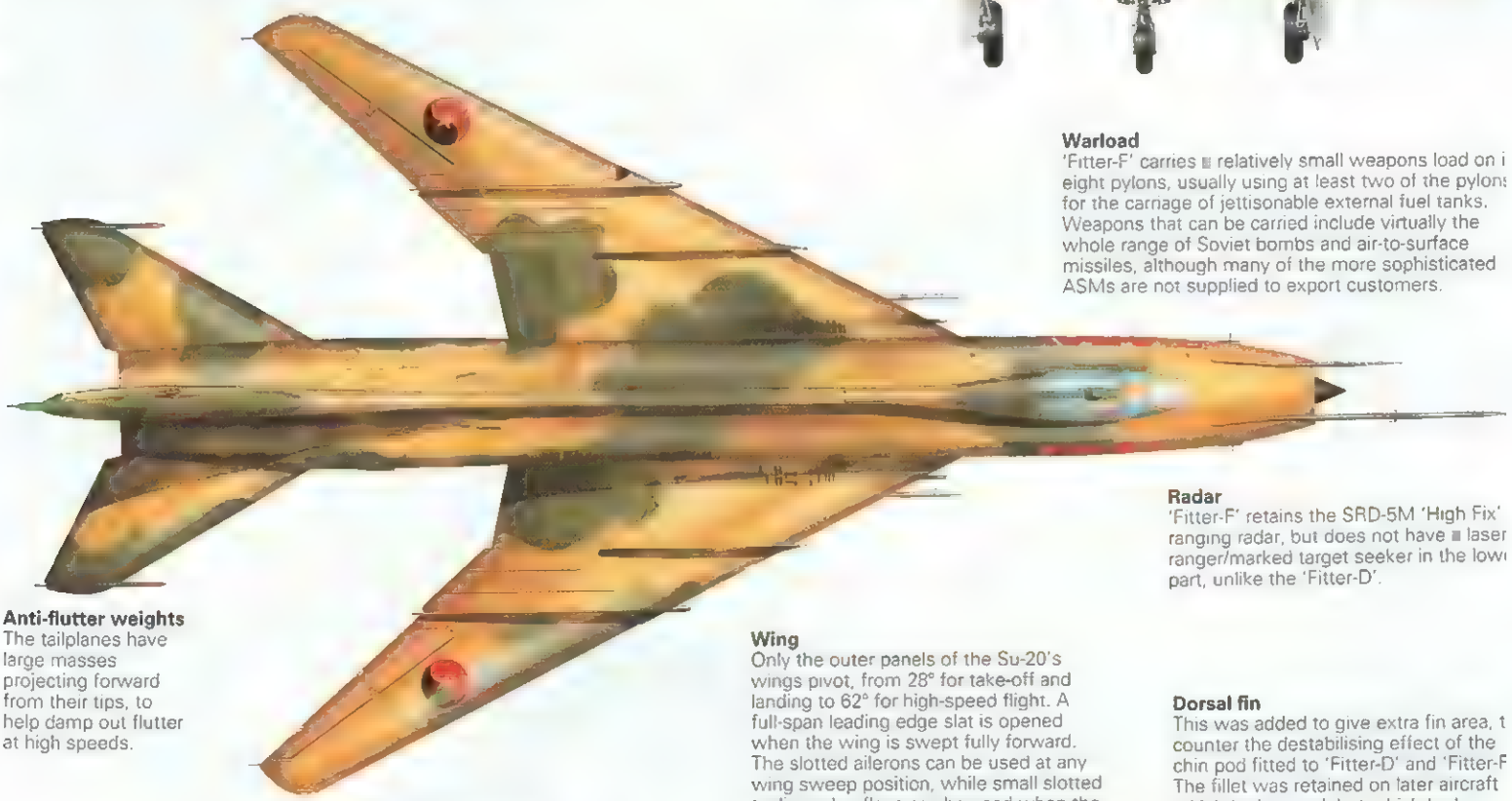
Su-20 'Fitter-F'

Whereas the Su-17s delivered to Poland were basically standard Soviet air force 'Fitter-Cs', those delivered to Libya and Peru from 1975 were sanitised and export derivatives of the Su-17M 'Fitter-D', using the same lengthened and drooping nose, but without a laser rangefinder and with a substantially downgraded avionics fit. The most noticeable external difference between the Libyan aircraft and Soviet 'Fitter-Ds' was the addition of a large fin leading edge extension, or fillet. The straight leading edge of the fin makes a sharp angle where it joins a new fin fillet. This modified fin profile increases keel area and helps to counteract the extensions to the forward fuselage introduced with the 'Fitter-D'.

The undernose electronics pod fitted to the Libyan aircraft is different from that of the Soviet 'Fitter-D', with the Doppler antenna being smaller and located farther aft. Most importantly they incorporate a new powerplant, the Tumanskii R-29BS-300, in place of the Lyul'ka AL-21F-3. The new engine is marginally more powerful than the Lyul'ka, producing 17,635 lb of dry thrust, or 25,350 lb with afterburning and water

Sukhoi Su-20 'Fitter-F'

The Su-20 'Fitter-F' is the export equivalent to the 'Fitter-D' and has basically the same airframe, but with a downgraded avionics suite. This aircraft wears the colourful markings of the Angolan air force, who have used the type operationally, and who regard the aircraft as a useful CAS aircraft, despite losing a number to hostile ground fire and SAMs. The designation and permanent base of the unit which operates these aircraft is unknown.



Warload
'Fitter-F' carries a relatively small weapons load on i eight pylons, usually using at least two of the pylons for the carriage of jettisonable external fuel tanks. Weapons that can be carried include virtually the whole range of Soviet bombs and air-to-surface missiles, although many of the more sophisticated ASMs are not supplied to export customers.

Radar
'Fitter-F' retains the SRD-5M 'High Fix' ranging radar, but does not have a laser ranger/marked target seeker in the lowe part, unlike the 'Fitter-D'.

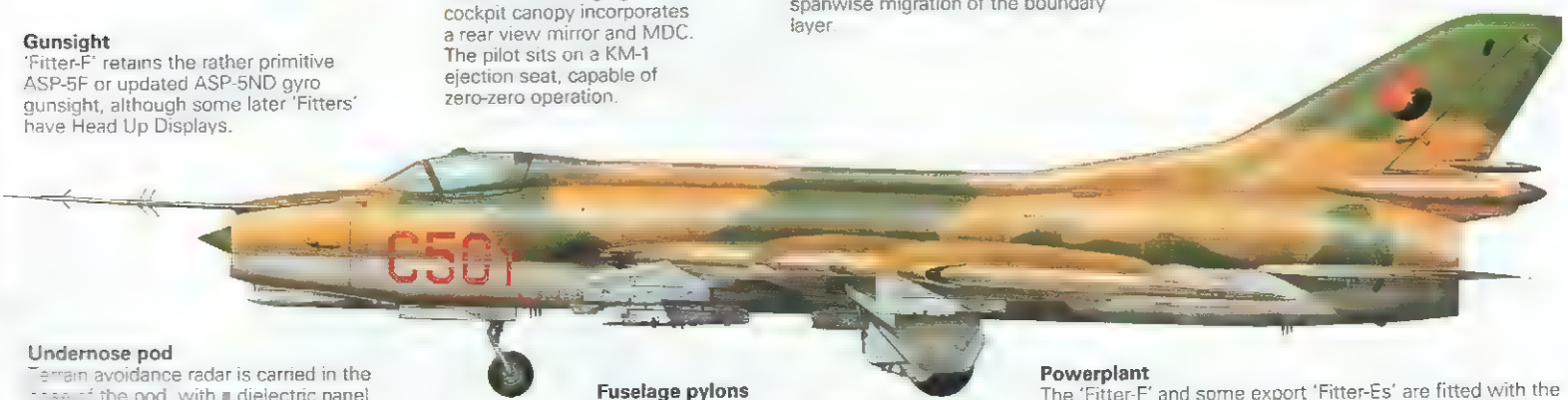
Anti-flutter weights
The tailplanes have large masses projecting forward from their tips, to help damp out flutter at high speeds.

Wing
Only the outer panels of the Su-20's wings pivot, from 28° for take-off and landing to 62° for high-speed flight. A full-span leading edge slat is opened when the wing is swept fully forward. The slotted ailerons can be used at any wing sweep position, while small slotted trailing edge flaps can be used when the wings are forward. Huge fences prevent spanwise migration of the boundary layer.

Dorsal fin
This was added to give extra fin area, t counter the destabilising effect of the chin pod fitted to 'Fitter-D' and 'Fitter-F The fillet was retained on later aircraft which had no pod, but which had a deeper nose.

Cockpit canopy
The rearward-hinging cockpit canopy incorporates a rear view mirror and MDC. The pilot sits on a KM-1 ejection seat, capable of zero-zero operation.

Gunsight
'Fitter-F' retains the rather primitive ASP-5F or updated ASP-5ND gyro gunsight, although some later 'Fitters' have Head Up Displays.



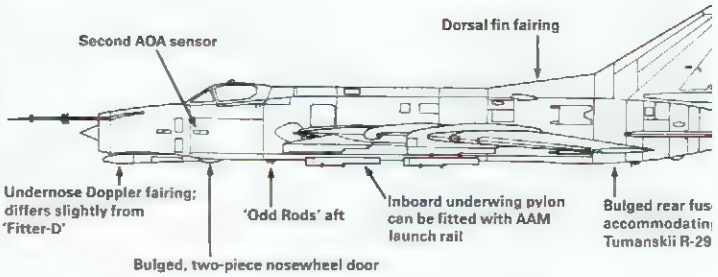
Undernose pod
Terrain avoidance radar is carried in the nose of the pod, with a dielectric panel behind it covering the Doppler navigation radar.

Fuselage pylons
'Fitter-F' carries tandem pairs of pylons under the belly. These can be used for the carriage of various types of air-to-ground ordnance, or for two 800-litre external fuel tanks.

Powerplant
The 'Fitter-F' and some export 'Fitter-Es' are fitted with the 25,350 lb st (with afterburning and water injection) Tumans R-29BS-300. The Lyul'ka AL-21F-3, by comparison, produce 24,690 lb st. The use of this engine in export aircraft reflects need to improve hot and high performance, and to provide commonality with the MiG-23 'Flogger'.

Sukhoi 'Fitter' variants

Above: A Libyan Su-20 'Fitter-F' in flight. Two aircraft like this were shot down by US Navy F-14 Tomcats on 19 August 1981.



Right: Fully armed Peruvian Su-20 'Fitter-Fs' line up at Lima International Airport, guarded by an armoured car, during a period of tension with neighbouring Ecuador.

injection. This engine is very similar to that fitted to the MiG-27, and has considerable commonality with all of the MiG-23/27 powerplants.

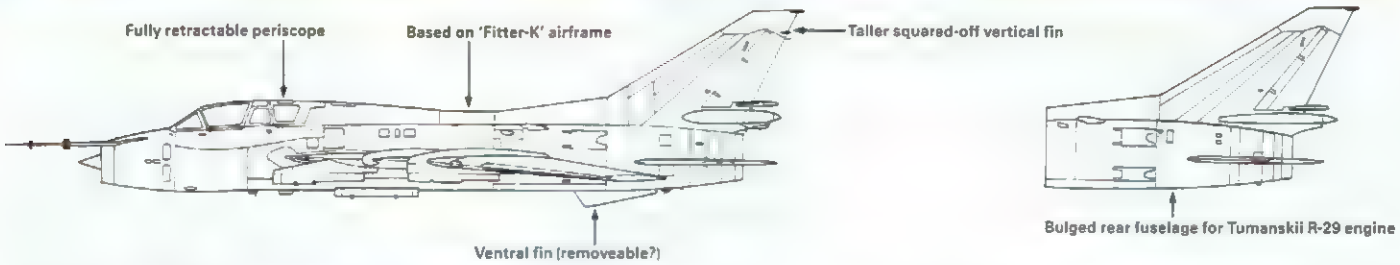
The Tumanskii engine is a much newer engine, a twin-spool turbojet with a higher pressure ratio (12.4), increased mass flow (235 lb/second) and reduced weight (3,705 lb). The engine is also considerably shorter than the Lyul'ka, and is fitted with a simple two-position afterburner. This results in the Tumanskii-engined 'Fitters' having a slightly shorter rear fuselage, and the six cooling inlets associated with the AL-21 are replaced by single inlets on each side of the spine. The entire rear fuselage of the Tumanskii-engined 'Fitters' is also slightly bulged, giving greater space around the engine and reducing the requirement for cooling airflow. It is not, as has been suggested, to accommodate the 'greater diameter of the new engine'.

Adoption of the Tumanskii engine for export aircraft may have been to provide commonality for air arms that also operated the MiG-23/27 family, or it may have been to ease production. About half of the Libyan air force 'Fitter' fleet of 90 aircraft consists of 'Fitter-Fs', equipping a Regiment at Okba Ben Nafi, formerly the USAF Wheelus Field.

Peru became a 'Fitter' operator in 1975, when F-5Es were not forthcoming from the US Government. Training was undertaken in Cuba, and 12 Cuban MiG-21bis were loaned to Peru as interim equipment. Peru's initial batch of 'Fitters' consisted of 32 'Fitter-Fs' and four Su-22U 'Fitter-E' two-seaters. These were assigned to Escuadron de Caza 11 'Los Tigres', and Escuadron de Caza 13 of Grupo 12 at Base Aerea Capitan Montes at Talara, on the Pacific coast close to the Ecuadorian border. The aircraft were intended to perform a secondary air defence role, and were equipped with K-13A AA-2 'Atoll' IR-homing AAMs. The Peruvian air force had minor problems in phasing in the new aircraft, and expressed some disappointment with the limited nature of the avionics fit, although Western reports that the IFF supplied was incompatible with SA-3 'Goa' SAMs also being delivered had no basis in fact. Most serious was the limited coverage (in sector and waveband) of the Sirena 2 RWR.

Unusually, this 'Fitter-F' has a las rangefinder and marked target seeker in the lower half of the intake centrebody.

Left: These Peruvian 'Fitter-Fs' ca underwing d tanks and ro pods under t bellies. The aircraft wear distinctive ti head badge Escuadron d Caza 11 'Los Tigres'.



Above: A Soviet air force Su-17UM 'Fitter-G' travels under tow. This variant has also been produced for export as the Su-22UM, sometimes with the Tumanskii R-29 engine.

Su-22UM Fitter-G'

This is believed to be the designation of the latest (presumably ultimate) two-seat version. This has the airframe of the M-3, with the extended vertical tail and removable underfin, combined with the front end and single gun of the Su-22U. The remarkable thing is that these trainers have been produced, often in quite small batches, with both the AL-21 and R-29 engines, the latter being for customers outside the Warsaw Pact.

The simplest way of identifying which engine is fitted is to see whether the curved fairing under the braking-parachute container meets the fuselage at the lip of the nozzle surrounding the afterburner nozzle (R-29) or has the form of an unpainted riveted titanium box whose lower edge is straight and meets the top of the fuselage 7 in ahead o nozzle (AL-21). The trainer has not b seen with the extra AAM pylons, bu those in Warsaw Pact service, certa including Poland and East Germany, chaff/flare dispensers.

A single group fairing is attached each side of the fin, firing upwards a outwards. Each fairing is held by six countersunk bolts and provides inte for two of the standard 32-tube disp boxes. Each tube can be loaded by I with ■ chaff cartridge or ■ flare. Onc installed, the boxes are permanently connected electrically, and all the pi has to do is switch the groups from to FIRE and then either select ■ mar mode (for example, pairs of ■ chose type of cartridge at a particular inter such as 1.5 seconds) or switch to th auto mode in which firing is controll the Sirena 3 warning system.

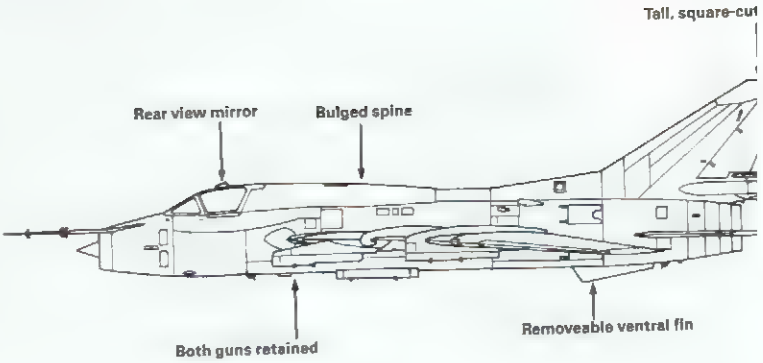
A pair of Frontal Aviation 'Fitters' airborne for a training mission. The lower aircraft is a single-seat 'Fitter-H', while the higher aircraft is a two-seat 'Fitter-G'. Two-seat VG Su-17/20/22s retain the 'Fitter' reporting name, unlike the swept-wing Su-7 two-seaters, which were 'Moujiks'.

Su-22M-1 'Fitter-H'

Given a designation in the Su-17 series by Soviet Frontal Aviation, and 'Fitter-H' by NATO, this is the single-seat counterpart of the S-32U just described. It is virtually identical, apart from several significant modifications. Of course there is no rear cockpit, the space being occupied by repositioned fuel-system components and avionics which in turn make room for more fuel, to a new high internal capacity of 1,379 Imp gal, considerably more than double the capacity of the original S-1 prototype. With the maximum of four 176-Imp gal drop tanks this brings the tankage for ferry missions up to 2,083-Imp gal, though this is hardly ever seen. The more common drop tank is the 600 litre (122 Imp gal), and not more than two are normally carried (on the fuselage or outer wing pylons, depending on the other stores). No inflight-refuelling probe has been fitted to this or any other Soviet tactical aircraft.

The most important change to the M-1 is the redesigned tail, which restores yawing stability degraded by the deeper forward fuselage and enlarged spine. The metal fin and rudder remain as before, but the dielectric cap, housing communications antennas, is considerably enlarged and squared off at the top. The aft-facing white navigation light can be mounted at the tip but is more commonly installed immediately above the rudder. On the underside of the fuselage is added a ventral fin extending from the wing trailing edge to the tailplane. This does not hinge to the side but is removable, and is frequently absent from single-seaters. On the corresponding trainers, however, it is almost always fitted. Of course the single-seat M-1 retains both guns, and these are reloaded through large upward-hinged hatches in the dorsal spine. Immediately ahead of these is a panel in the top of the spine which has been identified by Western analysts as a flush ADF (auto direction finding radio) antenna, though this is not confirmed. The M-1 has the pilot's rear-view mirror (not fitted to either canopy of the Su-17UM), and the fire-control air-data subsystem is augmented by a small total-temperature probe, a small tube looking like a miniature pitot, on the left side near the windscreen.

One of the first M-1s was seen carrying the considerable load of two UV-32-57 rocket launchers on the fuselage pylons, two AS-7 'Kerry' air-to-surface missiles on the inboard wing pylons and two K-13A ('Atoll') self-defence missiles on the outer pylons. About 165 similar aircraft are in service with Soviet Frontal Aviation in the reconnaissance role, normally carrying the multi-sensor reconnaissance pod on the centreline, active ECM jammer on the left inboard pylon and 122-Imp gal drop tanks on the outer pylons. It is believed that aircraft this family have been modified to carry chaff/flare dispensers as described under Su-22M-4.

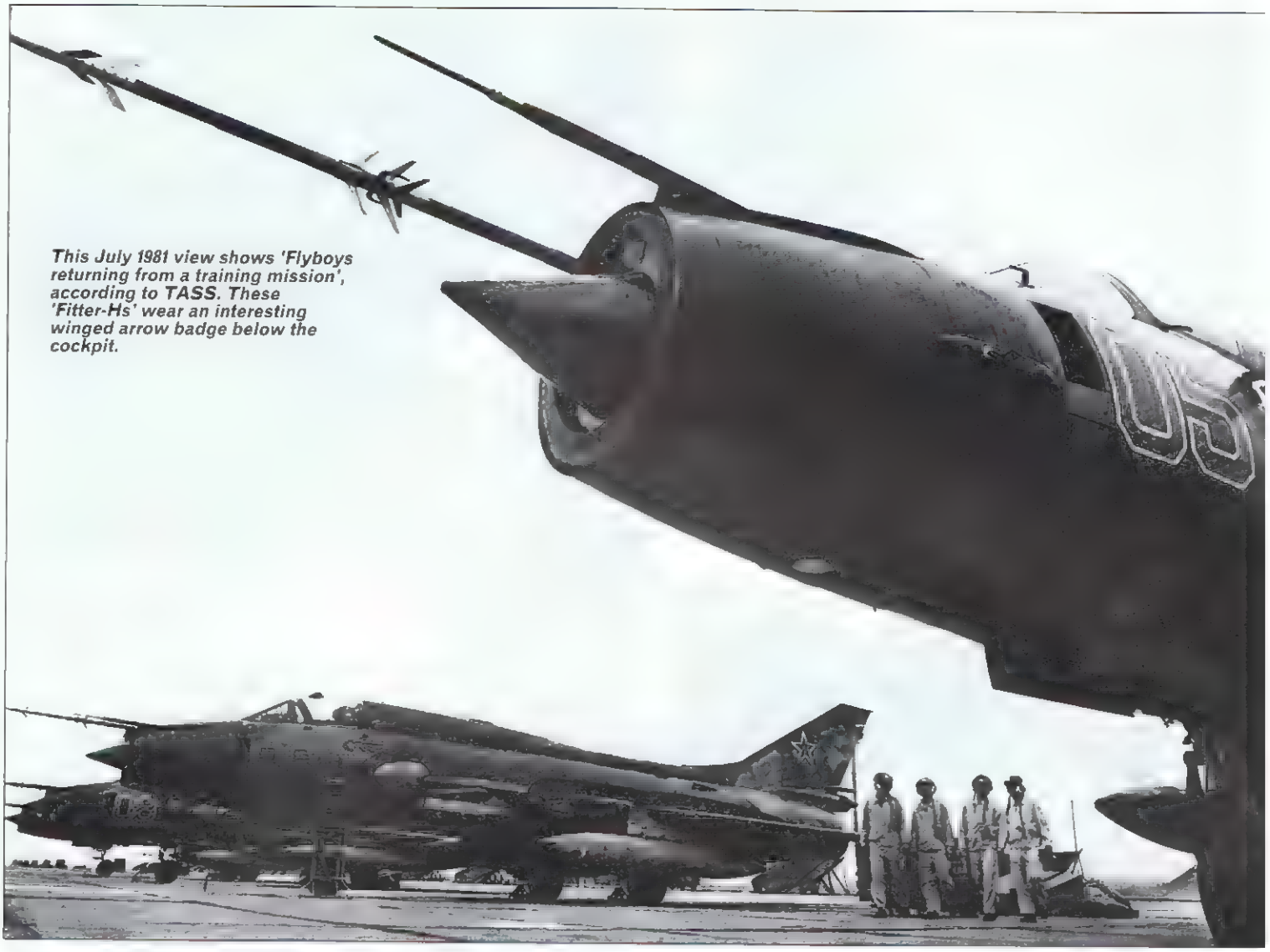


Above: Soviet aircrew walk down a long line of Su-22M-1 'Fitter-Hs'. The Soviet air force retains the Su-17 designation, although to Sukhoi they are Su-22s. The 'Fitter-H' introduced the larger, square-cut vertical fin and removable ventral fin.

Above: Soviet Frontal Aviation 'Fitters' now wear a subdued brown a green camouflage scheme, with the traditional white-outlined red sta carried large on the tailfin.

Above: This 'Fitter-H' carries a large multi-sensor reconnaissance pod under the fuselage, containing optical, infra-red, and radar-based sensors. Bombs could be carried in the armed recce role, perhaps with AAMs for self-defence.

Above: This 'Fitter-H' carries AA-2 'Atoll' IR-homing AAMs on the outboard underwing pylons for self defence, with AS-7-guided ASM inboard and two UV-32-57 rocket pods under the fuselage. The aircr wears a standard-of-excellence badge on the nose.



This July 1981 view shows 'Flyboys returning from a training mission', according to TASS. These 'Fitter-Hs' wear an interesting winged arrow badge below the cockpit.

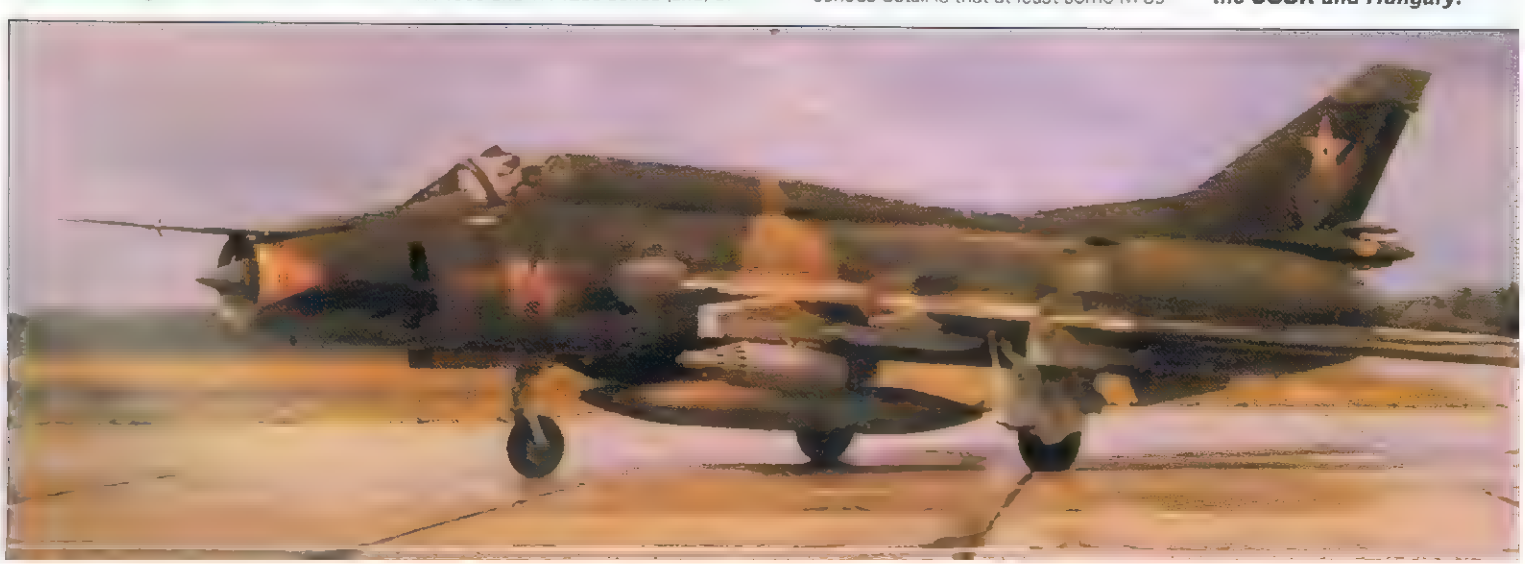
Su-22M-3 'Fitter-H'

This replaced the M-1 in production in 1980 or 1981. Still called an Su-17 by Frontal Aviation and the AV-MF naval aviation, and 'Fitter-H' by NATO, the M-3 is outwardly very similar to an M-1. The most obvious difference is the addition of AAM launching rails exactly midway between the two existing pylons, well ahead of the wing to clear the landing gear. These carry K-13A, R-60 or any other short-range self-defence missile.

The other change is a significant avionic upgrade, though the only obvious addition is a pair of blade antennas under the nose. ILS is fitted, though no information is available on the location of the localiser and glideslope antennas. The M-3 has been seen carrying the powerful AS-14 'Kedge' tactical attack missile on the inboard pylons, and is also capable of carrying nuclear weapons such as the TN-1000 and TN-1200 series (and, of course, such other weapons as PTAB/PTK cluster bomblet dispensers, BETA series concrete penetrators, ZAB incendiary stores, PLAB napalm, all the AB and AK chemical stores and large fuel/air explosive bombs). All M-3s have been retrofitted with chaff/flare dispensers.

The only non-Soviet user is Hungary's ML (Magyar Légierö), which received 40. These are based at Taszar, near the Yugoslav border, where they have been seen with a wide range of weapons. A curious detail is that at least some M-3s have landing or taxi lights on the m gears and possibly on the nose leg despite the retention of the power retractable lights under the forwarc fuselage. As in the later M-4, this g total of five 'headlights' at night!

The Su-22M-3 retained the designation 'Fitter-H' of the e Su-22M-1 and had an extra AA pylon underwing and an enha avionics suite. The only users the USSR and Hungary.

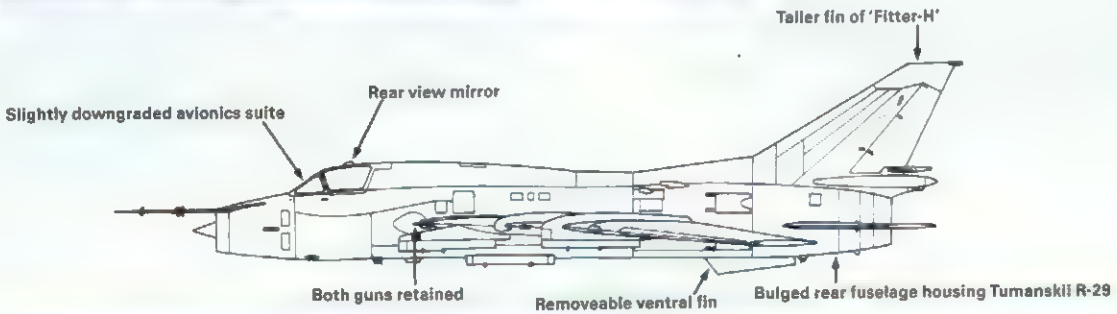


Su-22M-2 'Fitter-J'

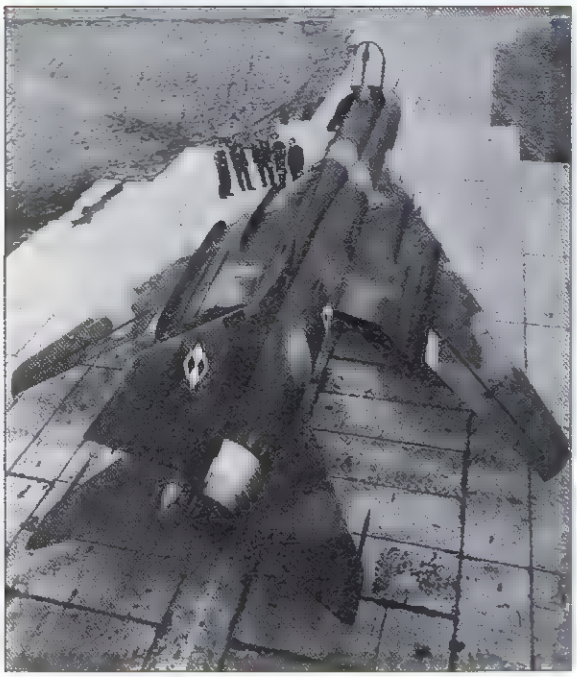
This is the export version of the M-1 and is virtually identical, apart from the switch to the Tumanskii R-29BS-300 engine. It is widely reported that the avionics suite is downgraded by comparison with that of the Soviet M-1, though (apart from the suggestion that the LRMTS (laser ranger and marked-target seeker) is replaced by a simple laser ranger, details are lacking. These aircraft have been sold to Angola, Libya, Peru, Syria, Vietnam and North and South Yemen. The Libyan Arab air force operates at least 50, some of which appear to have been retrofitted with chaff/flare launchers. At least one M-2 was shot down over Chad, and two more were destroyed in combat with F-14A Tomcats of US Navy squadron VF-41 on 19 August 1981 in the first known combat between swing-wing fighters. The Libyan aircraft have been tasked in the air-defence and ground-attack roles, but have not been seen with reconnaissance pods.

Despite the equipment limitatic experienced with its 'Fitter-Fs', th Fuerza Aérea del Peru was suffic pleased with its Sukhois to order second batch of 16 aircraft in 198 were delivered as Su-22M-2 'Fitt and equipped a single Escuadron within Group 11 at BA Mariano M La Joya in the south of the count 1984 the aircraft were considerat upgraded in an update programm involved the fitting of modern US avionics.

Above: Libya has augmented its original 'Fitter-Fs' with more modern 'Fitter-Js'. These are frequently encountered by NATO forces over the Mediterranean. Left: Peru ordered 16 'Fitter-Js' to join its 52 'Fitter-F' and 'Fitter-E' aircraft. This one is seen with a range of bombs and rockets.



Below: This air defence co Libyan 'Fitter-J' carries ext fuel tanks and AA-2 'Atolls'



Left: A Polish air force 'Fitter-K'. Polish 'Fitter-Ks' equip Regiments at Pila, Miroslawicz, Smardzko, Babimost and Powidz, serving alongside 'Fitter-Cs'.

Su-22M-4 'Fitter-K'

This was the final single-seat model to be produced. All M-4s are powered by the AL-21 engine, and the only recipients so far identified are the Soviet Frontal Aviation, Afghanistan, Czechoslovakia, East Germany and Poland. The principal new feature is a redesign of the air-conditioning and cooling system. The most obvious feature is the ram-air inlet, at the front of the dorsal fin, which has a diameter of about 75mm (3 in). Its face is vertical, and the gap between it and the top of the spine is filled by a vertical knife-edge which leads back into the full width of the fin. Inside the dorsal fin th duct from the inlet leads to the primary heat exchanger, the hot air then being dumped overboard through a grille on each side outlined in warning red. Curiously, many Western analysts have suggested that this inlet is in reality a forward-facing antenna, and they have not only produced drawings to this effe (ignoring the hot-air exit) but have also suggested that the engine-bay cooling has been revised, and drawn modified arrangements of ram-air inlets. In fact t cooling inlets are essentially the same a

Warload
The 'Fitter-K' retains eight dedicated weapons pylons, and these are used to carry a variety of stores, including the Type S-24 240-mm rocket, GSh-23L 23-mm cannon pods, UV-32-57 rocket pods, chemical weapons and the full range of 100-, 200-, 500- and even 1000-kg bombs, cluster, anti-runway, slick, retarded, incendiary or even tanks full of FAE or nuclear weapons.

The future
The 'Fitter-K' is the latest in a long line variants of this versatile fighter bombe Sukhoi have already produced the rath slower, more heavily armoured Su-25, and the larger, more sophisticated Su- but no direct replacement is in sight, a further 'Fitter' variants may well appea perhaps with a new, more economical engine or with increased internal fuel.

Camouflage
Polish air force 'Fitter-Ks' wear an attractive and effective green and brown colour scheme.

Sukhoi Su-22M-4 'Fitter-K

This 'Fitter-K' wears the colourful markings of the Polskie Wojska Lotnicze (Polish air force). The 'Fitter-K is the latest and most advanced 'Fitter', with much-improved avionics and equipment. The aircraft appea to be fitted with the new K-36D seat, as used by the MiG-29 and Su-27.

Engine installation
'Fitter-K' is powered by a Lyul'ka AL-21F-3, but this is given increased cooling through a number of vents and intakes, most noticeably at the base of the fin.

Operators
'Fitter-K' is operated by Frontal Aviation, Poland, Czechoslovakia, East Germany, and Afghanistan.

Defensive armament
Although its twin 30-mm cannon are primarily intended for strafing ground targets, they can be used against airborne targets, from enemy helicopters to opposing fighters. Additionally, the aircraft has the extra AAM pylons originally fitted to the Su-22M-3, carrying AA-2 'Atoll', AA-8 'Aphid' and perhaps AA-11 'Archer' IR homing AAMs.

in every other Sukhoi with the AL-21F-3 engine from the original Su-17 onwards.

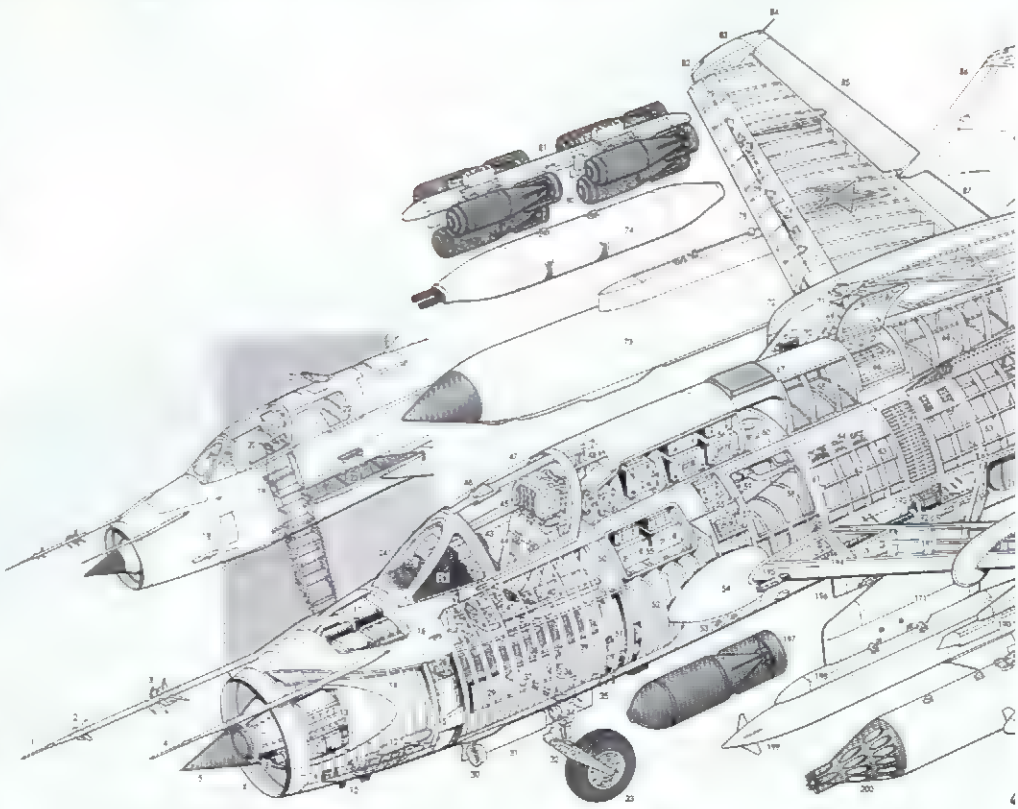
Of course the M-4 incorporates all previous updates and additions, including the blade antennas under the nose, the extra AAM rails, the five landing/taxi lights, extended fin, dorsal avionics transponder antenna and spine doors to the gun magazines. On each side of the unpainted titanium fairing under the braking-parachute box is a slim horizontal antenna which is also seen on some M-3s. No M-4 has been seen without the ventral fin, though doubtless this is still removable. An important innovation on the M-4, retrofitted to many earlier single-seaters in WP air forces, is that the fuselage was built with threaded bolt holes and electrical wiring for four twin groups of chaff/flare dispensers. The extra pair are located at the same level on each side of the spine at the mid-point of the fuselage, with a long gap between these dispensers and those further aft. The whole installation thus furnishes the pilot with a choice of no fewer than 256 expendable countermeasures, both chaff and IR flares, considerably more than are available on equivalent Western aircraft (most of which have none). The penalty is quite high drag, appreciably higher than if the four boxes on each side had been installed as one continuous tight group with a fairing at front and rear.

The M-4 can carry both forms of tactical reconnaissance pod, though this precludes use of the other two fuselage pylons. It has also been seen with a wide range of other stores, and doubtless can carry everything normally available to Frontal Aviation units, including the command-guided AS-7 'Kerry', AS-9 'Kyle' anti-radar missile, AS-10 'Karen' with TV or laser guidance, AS-11 'Kilter' with IR homing, AS-12 improved anti-

A Czech Su-22M-4 'Fitter-K'. Th aircraft are based at Namest, Prerov and Kralove, and are us in the ground attack and tactic reconnaissance roles. The 'Fitter-K' is a firm favourite wit Czech pilots, who praise its excellent ride at high speed.

radar missile and AS-14 'Kedge' thou to have mid-course guidance and te electro-optical homing. It is conceiva that some Su-17/22 versions will be rebuilt as dedicated electronic warfa Elint and reconnaissance platforms.

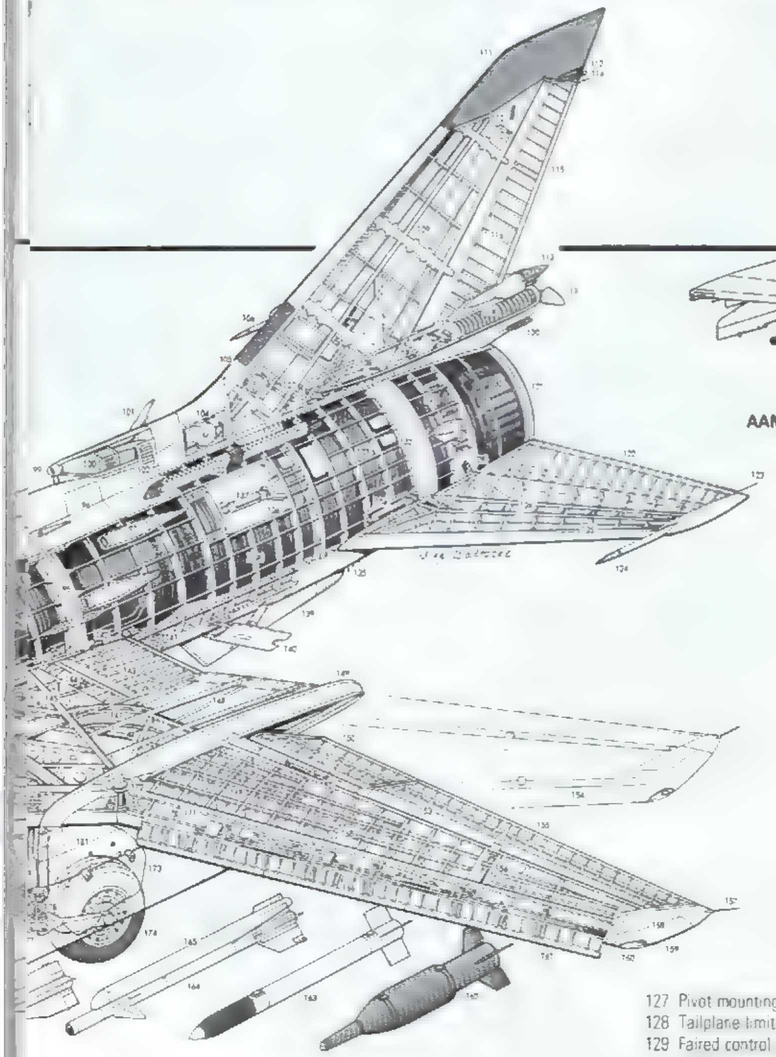
Sukhoi Su-22M-4 'Fitter-K'

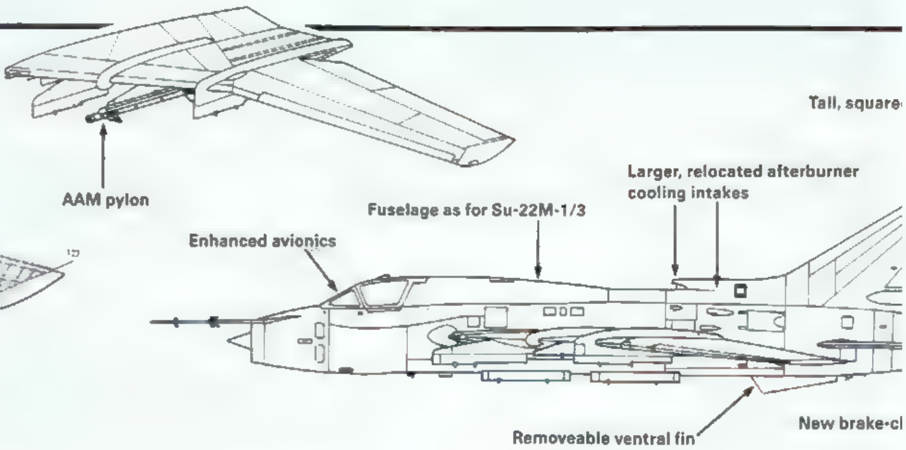


1 Instrumentation data probe
2 Yaw and pitch vanes
3 Fire control system computer transducers
4 Pitot head
5 Conical intake centre-body shock cone/radome
6 Engine air intake
7 'High Fix' I-band ranging radar
8 Laser marked target designator
9 Radar altimeter
10 Ventral antennas
11 Doppler navigation aerial
12 Angle of attack transmitter
13 Radar equipment module
14 Bifurcated intake ducting
15 Spring-loaded intake suction relief doors, open
16 Temperature probe
17 Nose avionics equipment compartment, ASP-5ND fire control system
18 Su-17 'Fitter-G' two-seat tandem trainer variant (nose profile)
19 Boarding ladder
20 Student pilot's cockpit
21 Retractable forward vision periscope
22 Instructor's cockpit
23 Rear cockpit access ramp
24 Armoured glass windscreen panels
25 Pilot's head-up display and attack sight
26 Instrument panel shroud
27 Control column
28 Rudder pedals
29 Nose undercarriage wheel bay
30 Retractable landing/taxiing lamp, port and starboard
31 Nosewheel doors
32 Nosewheel forks
33 Steerable nosewheel, forward-retracting
34 Nosewheel leg-mounted taxiing lamp
35 SRO-2M 'Odd Rods' IFF aerials
36 Nosewheel leg pivot fixing
37 Hydraulic retraction jack
38 Cockpit floor level
39 Close-pitched fuselage frames in pressurised section
40 Port side console
41 Engine throttle lever
42 Canopy latch
43 Rear view mirrors
44 Pilot's K-36 ejection seat
45 Ejection seat headrest
46 Mirror fairing
47 Cockpit canopy cover, upward-hinging
48 Canopy jack
49 Cockpit pressurisation valve
50 Rear pressure bulkhead
51 Air conditioning plant
52 Intake duct framing
53 Ground power and intercom sockets
54 Cannon muzzle blast shield/skin doubler
55 Avionics equipment racks
56 Dorsal fairing additional avionics equipment
57 Fuel system access panel
58 Intake trunking
59 Main fuel pumps
60 Inverted flight accumulator
61 Front wing spar attachment main frame
62 Centre fuselage frame and stringer construction
63 Fuselage fuel tanks
64 Fuel delivered ducting
65 Ammunition feed chute
66 Ammunition magazine, 70 rounds per gun, port and starboard
67 ADF aerial
68 Dorsal fuel tanks
69 Starboard wing fixed root segment
70 Strike camera
71 Wing pivot bearing
72 Outboard wing fence
73 Fuselage centreline tactical reconnaissance pod
74 GSh-23L cannon pod
75 Leading edge slats, down position
76 Slat hydraulic jack
77 Starboard wing integral fuel tank
78 Aileron hydraulic actuator
79 Slat guide rails
80 RPK-100, 220-lb (100-kg) bombs
81 Multiple ejector rack (wing glove and inboard pylons)
82 Starboard navigation light
83 Wing tip fairing
84 Static discharger
85 Starboard aileron
86 Starboard wing fully-swept position
87 Outboard single-slotted flap, down position
88 Wing glove section
89 Dorsal spine aft fairing
90 Forward chaff/flare dispensers, port and starboard
91 Wing main spar attachment double main frame
92 Engine compressor intake
93 Oil tank
94 Lyul'ka L-21F-3 afterburning engine
95 Rear fuselage break point (engine removal)
96 Access panels
97 Engine bay cooli air intakes
98 Engine turbine se
99 Heat exchanger intake
100 Primary heat exc
101 Starboard upper open
102 Cooling air spill
103 Rear chaff/flare port and starboa
104 Autopilot controll
105 HF aerial

Polish aircrew walk away from their 'Fitter-Ks' after a mission. The 'Fitter-K' has largely supplanted the older 'Fitter-C' in Polish service, although a small number of the older aircraft remain in use.

Above: The cockpit of an Afghan 'Fitter-K'. The cockpit is surprisi modern by Soviet standards, and bears a strong resemblance to tl the Su-25 'Frogfoot' and Su-27 'Flanker'. A MiG-21 or MiG-23 pilot w also quickly feel at home in this cockpit. The view forward is poor impeded by the high glareshield and heavily-framed HUD. The K-
ejection seat is standard on the latest Soviet combat aircraft.

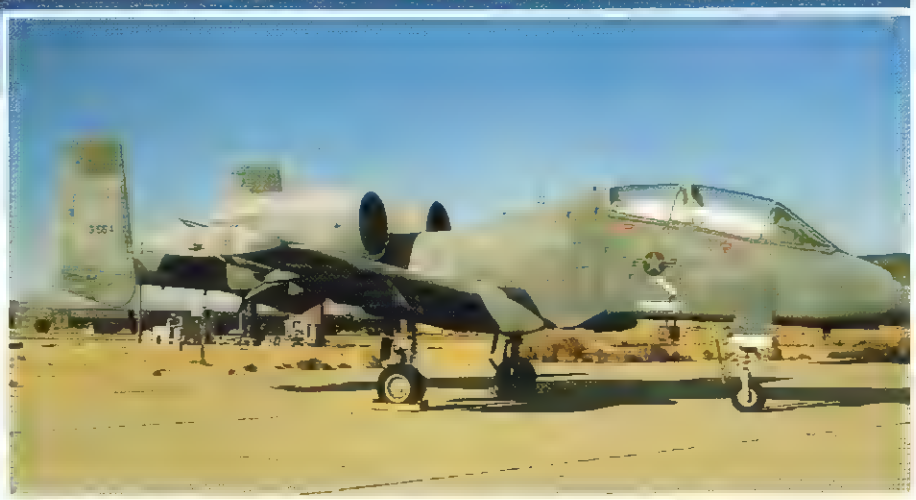


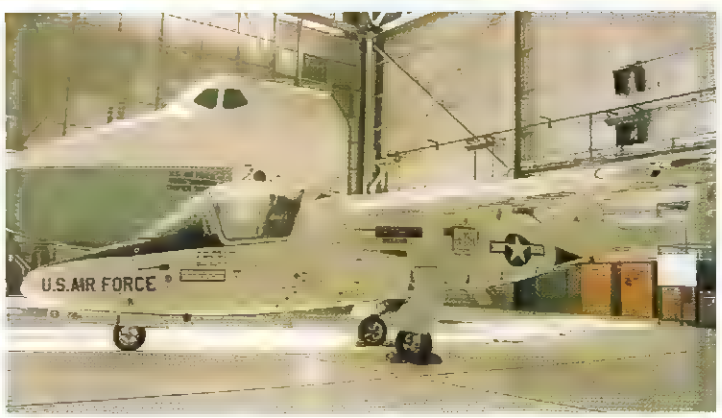


106 Starboard tailplane anti-flutter weight
107 Rudder control linkages
108 Rudder hydraulic actuator
109 Tailfin construction
110 [illegible] short-wave [illegible] aerial
111 Fin tip [illegible] aerial fairing
112 Rear Sirena-3 radar warning receiver
113 Tail navigation light
114 Rudder
115 Rudder rib construction
116 ECM aerial
117 Parachute release link
118 Brake parachute housing
119 Conical fairing parachute doors, open
120 Transponder aerial
121 Engine exhaust nozzle
122 Port all-moving tailplane
123 Static discharger
124 Tailplane tip anti-flutter weight
125 Tailplane rib construction
126 Tailplane spar
127 Pivot mounting
128 Tailplane limit stops
129 Faired control linkages
130 Variable area afterburner nozzle
131 Nozzle control jacks
132 Fin and tailplane attachment fuselage double frame
133 Afterburner ducting
134 Tailplane hydraulic actuator
135 SRO-2M 'Odd Rods' IFF aerial
136 Airbrake housing
137 Airbrake hydraulic jack
138 Rear fuselage frame and stringer construction
139 Ventral fin, detachable
140 Port lower airbrake, open
141 Engine accessory equipment access panel
142 Accessory equipment gearbox compartment
143 Port inboard single-slotted flap
144 Flap actuator
145 Auxiliary rear spar
146 Wing sweep control hydraulic jack
147 Rear spar guide rails
148 Wing glove section external stiffeners
149 Outboard wing fence
150 Outboard single-slotted flap
151 Flap rib construction
152 Flap actuator
153 Aileron rib construction
154 Port wing fully-swept (60-degree) position
155 Port aileron
156 Aileron hinge control linkage
157 Static discharger
158 Wing tip fairing
159 Port wing fully-forward (30-degree) position
160 Port navigation light
161 Three-segment leading edge slats, down position
162 BETA B-250 250-kg (550-lb) retarded concrete-piercing bomb
163 S-24 240-mm aircraft rocket
164 AA-2 (K-13A) 'Atoll' air-to-air self-defence missile
165 Missile launch rail
166 Leading edge slat rib construction
167 Aileron hydraulic actuator
168 Port wing integral fuel tank
169 Wing rib construction
170 Leading edge slat hydraulic jack
171 Outer wing panel main spar
172 Wing pivot bearing
173 Mainwheel doors
174 Port mainwheel
175 AA-8 'Aphid' air-to-air self-defence missile
176 600-litre (122-Imp gal) external fuel tank
177 Levered suspension axle beam
178 Leg mounted landing lamp
179 Main undercarriage leg strut
180 Leg rotating and shortening link
181 Outboard wing pylon
182 Main underca fixing
183 Hydraulic retr
184 Fixed wing ce main spar
185 Main underca bay
186 Inboard wing
187 Front spar
188 Forward secto radar warning
189 Intermediate
190 AA-8 'Aphid'
191 Leading edge
192 NR-30 30-mm and starboard
193 Cannon and a feed drive
194 Recoil mounti
195 Cannon muzzl
196 Fuselage RK-5 pylon, two ea starboard
197 FAB-500 500- HE bomb
198 Missile launch
199 AS-7 'Kerry' a missile
200 UV-32-57 rock (32×57-mm fi aircraft rocket

Edwards On Show

Edwards AFB was established during the war as Muroc Army Air Base, and renamed in 1950 after Captain Glen W. Edwards, killed in the crash of a Northrop YB-49 bomber. Its first use as a test site came in October 1942. Since then it has evolved into the largest and most famous air test centre in the world. Irregular open days provide a unique glimpse into the test world and the based aircraft.





Left: The principal aircraft operating unit of the Air Force Flight Test Center at Edwards is the 6512th Test Squadron. Vought A-7Ds serve in numbers.

Above: The Fairchild T-46A wa intended as a successor to the Cessna T-37, but was not adop The prototype remains at Edw for the base museum.

Above: The Lockheed SR-71 had a close association with Edwards, having used the base for its 1976 speed records. This example, 64-17972, was on the strength of the 2762nd Logistics Squadron at nearby Palmdale. In the 1989 Edwards display it made the type's last airshow appearance.

Below: NASA operates the Hugh L. Dryden Flight Research Facili at Edwards. Among its aircraft is this Vought F-8C Crusader, fitted with a fly-by-wire system to imit certain flight characteristics of t Space Shuttle. It first flew as su in 1978.

Above: One of the tasks of the 6512th TS is to provide aircraft for the Test Pilot School. Here the five main types fly in formation, comprising McDonnell Douglas NF-4E, General Dynamics F-16A, Northrop T-38A, Vought A-7D and Cessna NOA-37B.

Left: With its testing days over, the sole Fairchild YA-10B sits out on the airfield awaiting display in the base museum. The two-seat 'Warthog' was developed as a company-funded night/all-weather attack platform with FLIR and other sensors.

The 6512th TS has a B-52G (illustrated), B-52H and a pair of B-1Bs for bomber test duties. Regular visitors to Edwards are the various C-135s of the 4950th Test Wing at Wright-Patterson AFB, Ohio, who provided this NKC-135E for a refuelling demonstration with the B-52. Other 4950th C-135s perform a myriad of sensor and equipment tests.

NASA's test fleet is kept in immaculate condition, as evidenced by thi superb Martin RB-57B Canberra used for high altitude test work. It bea the civil registration N809NA and is suitably modified with air data probes. Other NASA activities at Edwards include support of the Shut programme, with training aircraft and simulators.

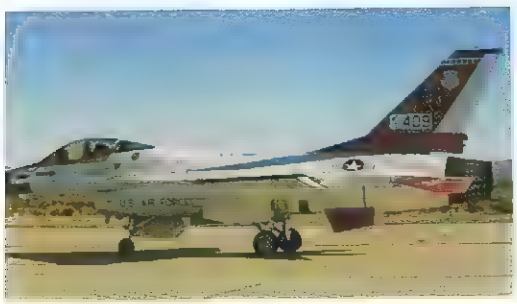
Left: A Lockheed MC-130E of the 8th SOS performs a practice Ful recovery during tests from Edwards. Note the cable being snagged by the forks on the aircraft, the red tags on the cabl to give the pilot aiming cues, an the weighted cable suspended from the open ramp ready to cat the main cable. Also on test at Edwards now is the MC-130H updated version of the Special Forces Hercules, although this does not feature Fulton gear.

Below: Bell UH-1Ns are used by the 6512th TS for utility duties around the base, including resc work.

Left: One of NASA Dryden's best-known aircraft is the Boeing NB-52I one of two aircraft procured to support the North American X-15 programme. It then went on to provide support for the Martin X-24 an other projects, and is still current, being primarily employed on tests the Pegasus air-dropped space launch vehicle.

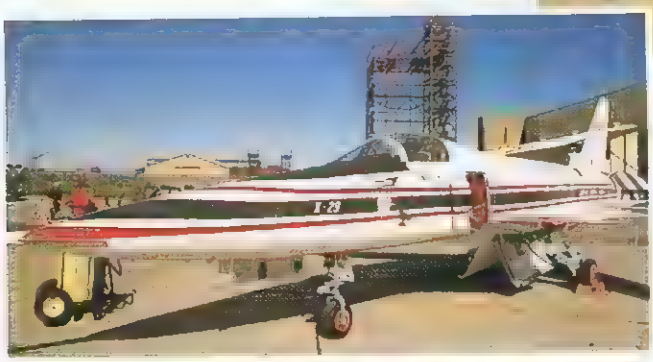
Right: The 4950th Test Wing provides NKC-135 aircraft for air refuelling compatibility tests of Edwards-based aircraft. Here a 6512th TS NF-4E Phantom makes contact.

Below: 'Aardvarks' such as this F-111A serve with the 6512th TS to provide equipment and weapons test vehicles. In the background are some of the radars and monitoring systems that ring the vast test site.



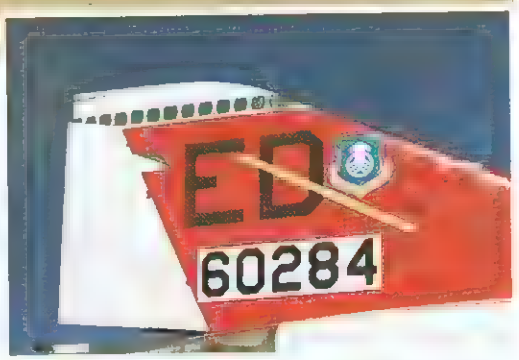
Above: The 6512th TS uses the F-16A for both chase and test pilot training duties.

Below: NASA Dryden's most exciting aircraft are the two Grumman X-29A Forward Swept Wing technology demonstrators.



Above: Disused aircraft are dotted around the vast Edwards complex, to be brought together in a base museum. Among them is this Fairchild C-123K Provider, wearing full South Vietnamese air force markings.

Right: The red and white colour scheme applied to many 6512th TS aircraft is for conspicuity. Note the Systems Command badge.



A unit with a sizeable presence at Edwards is the US Army Aviation Engineering Flight Activity (USAAEFA), which maintains examples of the current service types for ongoing tests. This is a UH-60A with ferry tanks fitted.

F-16s are much in evidence at Edwards, testing new equipment for the type. This F-16B is fitted with LANTIRN pods, the FLIR/TFR targetting and navigation equipment that turns the F-16 into a true all-weather attack platform.

A fixed-wing type assigned to the USAAEFA is this Beech JU-21A, the 'J' prefix denoting temporary test status. This is used for utility and liaison work in addition to any trials it is called upon to perform.

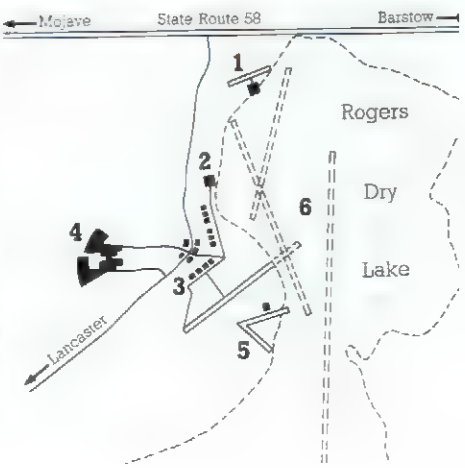
Left: The F-15 S/MTD is a joint McAir/USAF programme to explore the performance and manoeuvrability advantages gained by large canard foreplanes and thrust-vectoring nozzles. Another important manufacturer programme under way here is the General Dynamics AFTI/F-16 which is testing advanced fighter technology.

Above: Other regular Edwards visitors are the five immaculate Convair F-106s assigned to Rockwell B-1B chase duties at nearby Palmdale, where the bombers (and many other US military aircraft) are built. A pair of single-seat F-106As are used and three F-106B two-seaters. Fins are painted in either red, blue or black.

Edwards AFB

Situated some 70 miles to the north of Los Angeles, and 25 to the north of the major manufacturing facility at Palmdale, Edwards is perfectly placed to perform its tasks. The vast Rogers Dry Lake has several runways marked out, while the surrounding hills provide suitable ground launch facilities for rockets. The main base supports most Air Force Flight Test Center and NASA activities. The rarely seen North Base is used for classified work, and was once the CIA headquarters for its U-2 operations.

1 North Base – site of most classified activity
2 NASA Dryden Facility – performs high-speed and high-altitude work as well as Shuttle support. Taxiway leads to main runway
3 Main Base – the single 15,000 ft concrete runway, thought to be world's longest, is set well away from the main ramp and buildings. Large collection of hangars and ramps support main AFFTC activities, leading round to the NASA facility
4 Housing and administrative area
5 Old South Base – original facility established here. Runways not used but present site for Northrop B-2 test facility hangar
6 Lake bed runways – seven in total, three longest shown



United Kingdom
Air Arms

An unusual set of circumstances has shaped the United Kingdom's armed forces since the formation of NATO in 1949. Principal amongst these have been the diminishing but still significant ties with current and former overseas possessions; the requirement to maintain a military presence on the Continent; and continuation of the World War II role of democracy's 'unsinkable aircraft-carrier' off the European coast. In the last-mentioned connection, resident and reinforcement aircraft from the USA would result in the British Isles acting as a base for 40 per cent of NATO's air strength on the eve of a war – and though the threat of such an event has receded greatly in recent months, gradual and not drastic cuts in aerial strength are planned for the future. In the words of Defence Secretary Tom King, "We cannot be certain where or how our interests and our freedoms may next be threatened; and we must remain able to meet the challenges with a skilful and effective response." Few forces are more skilful and effective than the UK's air arms.

'Defend and Strike' sums up Strike Command's tasks.

RAF Germany is the secon front-line organisation.

The Panavia Tornado GR.Mk 1 is the most important strik aircraft in Royal Air Force service, tasked mainly with interdiction missions. This is a No. 14 Sqn aircraft.

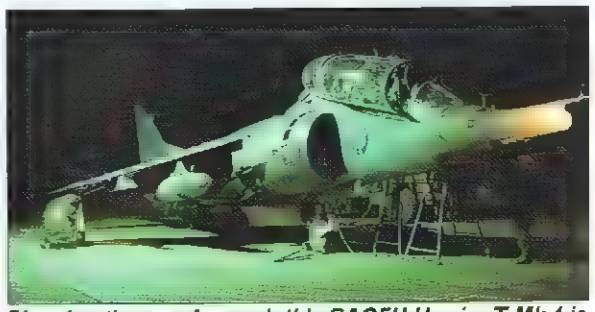
The Royal Air Force

1990 is a year of high profile for the RAF as it celebrates the 50th anniversary of the Battle of Britain. In saving the country – and, indirectly, human freedom over a large area of the globe – the Service demonstrated that air power is an essential adjunct to conventional military warfare on land and sea. Although the British Navy and Army have air elements, both continue to rely upon the RAF to provide at least some of their requirements. Strategic nuclear deterrence is no longer an RAF responsibility, having passed from the V-Bombers to Polaris submarines on 1 July 1969, but at theatre level the Tornado fleet is a powerful force.

At its highest strata, the RAF is administered by the Air Force Board, comprising nine members, only three of whom are in uniform. Responsible to the Board are the three equal-status divisions of today's RAF: Strike Command, Support Command and RAF Germany. Personnel strength is 89,600, including 6,600 women, to which may be added wartime reserves of 38,100 and Volunteer or Auxiliary forces numbering 1,400. Aircraft (apart from gliders) total 1,700, including 650 of front-line types, 450 being immediately available for operations according to NATO readiness criteria. Approximately one-third of the £21,223 million 1990–91 UK defence budget is assigned to the RAF – directly in the case of £3,668 million for strike/attack/reconnaissance forces, or in other ways, such as training, R&D, repairs, stocks and central administrative support.

With Foxhunter radar, Sky Flash radar-homing missiles a Sidewinder heat-seekers, the Tornado F.Mk 3 is the main airborne defence asset against intruders.

Developed with McDonnell Douglas, the Harrier GR.Mk 5 a new generation variant of the trusty STOVL attack platform. It has introduced vastly increased capability.



Showing the way forward, this SAOEU Harrier T.Mk 4 is fitted with 'Nightbird' equipment for night and bad weath operations. Harrier and Tornado will be so equipped

STRIKE COMMAND

The major proportion of the RAF's 'sharp end' is concentrated within Strike Command, only the forces based in Germany having duties parallel to some elements of the Command. Inevitable contraction of the RAF resulting from withdrawal from empire, abandonment of conscription and escalating costs has resulted in several specific commands being merged into this all-embracing title. Formed on 30 April 1968, Strike Command since 10 April 1975 has been fully integrated with NATO, by which it is known as United Kingdom Air Forces. In wartime, the Air Officer Commanding-in-Chief of Strike Command would don the alternative 'hat' of CINCUKAIR, being responsible to SACEUR for defence of the UK and provision of air forces to support other NATO [illegible] in the Command are 800 aircraft, 49,000 uniformed personnel and 5,000 civilians.

From headquarters at (and underneath) Na-phill, near High Wycombe, RAF STC presides over two lodger units and other directly-controlled organisations further afield.

The first two are the Central Tactics and Trials Organisation and the Royal Observer Corps. CTTO's role is adequately explained by its title and by the development work undertaken by its small fleet of Tornado GR.Mk 1s, Tornado F.Mk 3s and Harrier GR.Mk 5s operated by the Strike/Attack Operational Evaluation Unit at Boscombe Down and Tornado F.Mk 3 OEU at Coningsby. The ROC, which was run down in the 1960s to a fallout-reporting organisation, has now regained some of its former role as a voluntary organisation reporting wartime aircraft movements as a back-up to radar.

Outside High Wycombe are the combat and

UK Air Bas

The majority of UK air bases are located in a wide swathe that ru Wiltshire through to North Yorks Notable for the lack of air bases Scotland, Wales and south-west England, largely on terrain grou Other overseas bases are locate Gibraltar (RAF detachments, Na flight), Brunei (Army detachmen Hong Kong) and Suffield in Can the latter providing a training gr for the Army.

KEY

- RAF Strike Command
- RAF Support Command and others
- Army Air Corps
- Royal Navy
- Ministry of Defence (Procurement Executive)
- ★ US Air Force

supporting aircraft of Nos 1, 11 and 18 Groups, Air Headquarters Cyprus, the Military Air Traffic Organisation and smaller, direct-reporting units. MATO is entirely concerned with other people's aircraft, although some of the direct-reporting establishments are so small that they are scarcely able to scrape together a squadron.

Not so far mentioned, the RAF Regiment undertakes defensive duties at RAF bases, such as providing Rapier SAMs or protecting Harrier detachments in the field. Regiment squadrons are allocated to appropriate Groups of STC and have no central organisation of their own. Similarly, the Royal Auxiliary Air Force and RAuxAF Regiment squadrons are non-centralised. They, too, operate no aircraft, but provide a most capable back-up to the regular forces in diverse fields including anti-aircraft guns, maritime headquarters, air cargo despatch and aerodrome defence.

No. 1 Group

Just as Strike Command is the largest single element of the RAF, its No. 1 Group is the major home-based air component. With HQ at Upavon, the Group perpetuates the traditions of the old Bomber and Transport Commands, flavoured with a reconnaissance element and the short-lived (1960-67) separate air mobility force of tactical transports, helicopters and supporting fighter-bombers.

With the majority of operational Panavia Tornado GR.Mk 1s now based in West Germany, Bomber Command's successors may be regarded as merely the two squadrons (Nos 27 and 617) of these interdictors based at Marham. Assigned to SACEUR's Strategic Reserve (Air), both units are also believed to have national roles, although in either case their mission would be to attack pre-determined locations with WE177 nuclear bombs.

There are some 385 of this free-fall weapon in existence, of which 245 are assigned to Tornados and maritime-strike Buccaneers (and the balance to Nimrods). Yield may be varied, up to a maximum of 500 kilotons. To reduce aircraft vulnerability, Staff Requirement (Air) 1244 has been formulated for a stand-off replacement for WE177 which will enter service towards the end of this decade. America's TASM and SRAM 2 are under consideration, as is a joint, longer-range development of the French ASMP which would be known as ASLP.

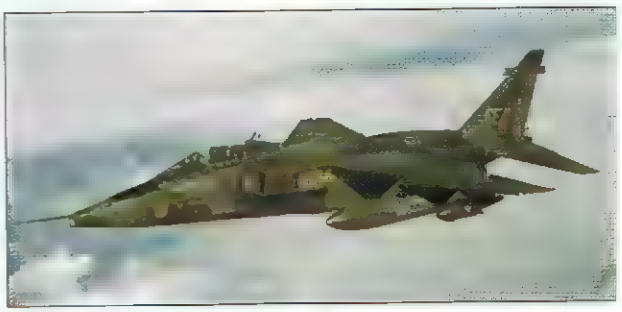
Marham's wing was established in 1983. At Honington, No. 9 Squadron formed during the previous year, but was transferred to Germany in 1986. Its place was taken on the first day of 1990 by the newly-established No. 13 Squadron, equipped with Tornado GR.Mk 1As in the reconnaissance role, but also able to dispense conventional weapons. No. 13 was the last of the planned 11 Mk 1 squadrons, but the first Tornado unit – in any air force – remains at Cottesmore, where the Trinational Tornado Training Establishment receives crews from West Germany and Italy, as well as the RAF. With a fully international complement of aircraft and staff sharing responsibilities, TTTE recently turned out its 2,000th graduate.

Having learned to fly the aircraft, crews go their different national ways to develop combat skills. At Honington, the Tornado Weapons Conversion Unit trains RAF personnel before they join a combat unit. TWCU aircraft wear the insignia of No. 45 Squadron, which identity they would adopt in wartime, crewed by teaching staff. Such 'shadow' squadrons are assigned to some OCUs, although their correct title is Reserve Squadron.

Strike Command's refuelling fleet has become indispensable for daily operations such as long-range interception and overseas deployment. Only one Victor squadron remains, shortly to be withdrawn when the fully modernised force is completed in the form of nine TriStars and 14 VC10s – plus eight transport VC10s with optional tanker roles. Electronic aircraft of No. 1 Group include Benson's No. 115 Squadron, whose Andovers calibrate aerodrome and inflight navigation aids as well as having a wartime role of communications relay.

Upgrading of the close-support force has recently involved Wittering-based No. 1 Squadron trading in BAe Harrier GR.Mk 3s for the greatly improved GR.Mk 5 model. No. 1 is assigned to SACEUR's strategic reserve, and regularly deploys to Norway on reinforcement exercises as well as practising operations from RN carriers. The Coltishall SEPECAT Jaguar Wing has benefitted from mid-1980s installa-

Only two Tornado GR.Mk 1 strike squadrons operate within No. 1 Group, both from RAF Marham. This aircraft is from No. 617.

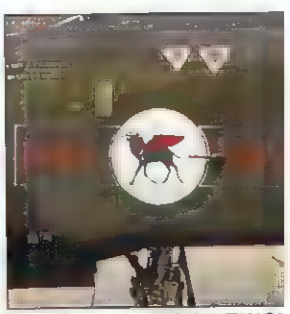


Although now retired from RAF Germany, three squadrons and an OCU still fly the SEPECAT Jaguar GR.Mk 1 with No 1 Group. This aircraft is from No. 54 Sqn.

No. 6 Sqn Jaguars wear a 'Flying Tin-opener' badge commemorating the squadron's wartime tank-busting exploits. This was undertaken in the desert with Hurricanes.

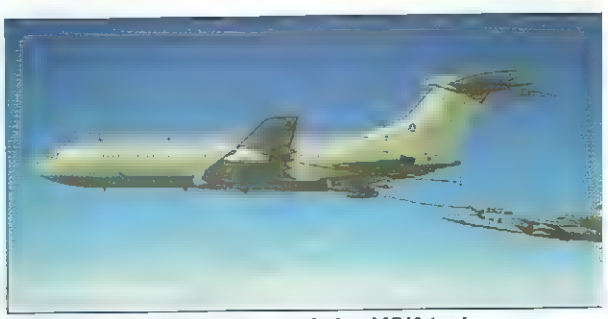
No. 41 Sqn flies the Jaguar i the reconnaissance role fro its base at Coltishall.

Among the newest RAF squadrons is No. 13, based at RAF Honington.

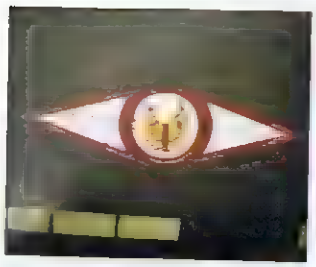


The Tornados of the TWCU at Honington wear the winged camel badge of No. 45 Sqn.

A handful of Victor K.Mk 2 tankers remain active with No. 55 Sqn at Marham, but their days are numbered as more capable TriStar and VC10 tankers are converted.



No. 101 Sqn operates a fleet of nine VC10 tankers, exemplified by this K.Mk 2 refuelling a No. 5 Sqn Tornado More VC10s are being converted for the tanker role.

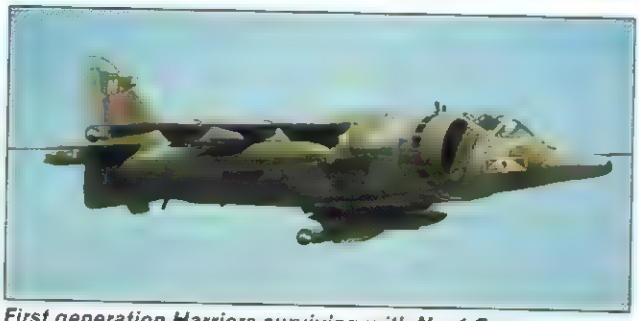


The winged '1' adorns the Harrier GR.Mk 5s of that numbered squadron.

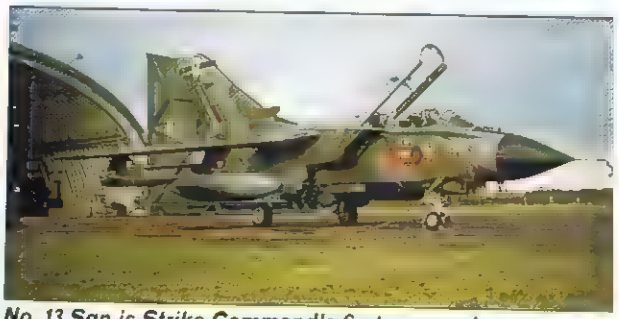
The McDonnell Douglas/British Aerospace Harrier GR.Mk 5 has vastly increased capability compared to the original GR.Mk 3, chiefly in weapon load and range characteristics. A much larger and more efficient wing is employed, although the engine remains similar. Avionics have also been upgraded to give greater accuracy.

No. 54 Sqn's Jaguars wear a rampant lion on the nose, in addition to checks.

No. 617 Sqn's lightning flashes are adopted from the squadron badge, which shows lightning flashing over a breached dam. The squadron's unofficial name is 'The Dam Busters'.

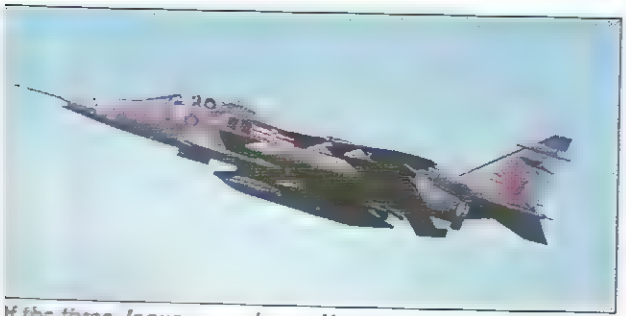


First generation Harriers surviving with No. 1 Group are assigned to No. 233 OCU for training duties. The unit also has the updated GR.Mk 5 and T.Mk 4 two-seaters.



No. 13 Sqn is Strike Command's first reconnaissance Tornado unit, flying the GR.Mk 1A variant. This has the guns removed in favour of an infra-red linescan system.

Strategic transport is the domain of No. 10 Sqn, flying VC10 C.Mk 1s from Brize Norton. The aircraft are due to be given tanking capability.



Of the three Jaguar squadrons, No. 41 is assigned the tactical reconnaissance role. A camera and infra-red linescan pod is carried on the centreline.

A Harrier GR.Mk 5 of No. 1 Sqn manoeuvres hard. The Harrier has always been remarkable for its agility, particularly useful over the battlefield. Enhancing agility on the GR.Mk 5 are leading-edge root extensions.

tion of the highly accurate Ferranti FIN1064 inertial navigation system.

Nos 6 and 54 Squadrons are classed as Regional Reinforcement squadrons for NATO flanks. No. 6 additionally having a national commitment to the UK Mobile Force. No. 41 Squadron is a dual reconnaissance/attack squadron committed to Allied Command Europe Mobile Force (NATO parallel to the UKMF). Nearly 90 Jaguars, including 19 two-seat T.Mk 2As, remain in the active inventory. Their replacement – and also that for the Phantom – will be the European Fighter Aircraft (EFA).

Helicopter support primarily emanates from Odiham, where No. 7 Squadron has some of the RAF's 35 Boeing Vertol Chinooks, all of which are to be upgraded to Mk 2 standard during the early 1990s, making them equal to the US Army's CH-47D. Half of the 44-strong Westland/Aérospatiale Puma fleet is also at Odiham, notably with No. 33 Squadron. These two squadrons are assigned to NATO's Central Region in wartime with ACE MF and the UK MF. A provisional commitment has been made to 25 EHI EH.101 Merlins to modernise the Support Helicopter Force, but that may yet be replaced by an order for Sikorsky Black Hawks and more Chinooks. The vital transport force of 61 Hercules (six of them tanker-capable) and VC10s anticipates no significant changes in the near future.

No. 1 Group Units

UNIT	EQUIPMENT	BASE
(Supporting aircraft marks/types in parentheses)		
Strike/attack squadrons:		
No. 27 Squadron	Tornado GR.Mk 1	Marham
No. 45 Squadron	see TWCU	
No. 617 Squadron	Tornado GR.Mk 1	Marham
Close air support/attack squadrons:		
No. 1 Squadron	Harrier GR.Mk 5	Wittering
No. 6 Squadron	Jaguar GR.Mk 1A (T.Mk 2A)	Coltishall
No. 54 Squadron	Jaguar GR.Mk 1A (T.Mk 2A)	Coltishall
Tactical reconnaissance (secondary attack) squadrons:		
No. 13 Squadron	Tornado GR.Mk 1A (Mk 1)	Honington
No. 41 Squadron	Jaguar GR.Mk 1A (T.Mk 2A)	Coltishall
Aerial refuelling squadrons:		
No. 55 Squadron	Victor K.Mk 2	Marham
No. 101 Squadron	VC10 K.Mk 2/3	Brize Norton
Strategic transport squadrons:		
No. 10 Squadron	VC10 C.Mk 1	Brize Norton
No. 24 Squadron	Hercules C.Mk 1/1K/3	Lyneham
No. 30 Squadron	Hercules C.Mk 1/1K/3	Lyneham
Strategic tanker/transport squadron:		
No. 216 Squadron	TriStar K.Mk 1/ C.Mk 1/Srs 500	Brize Norton
Transport squadrons:		
No. 32 Squadron	Andover C.Mk 1/ CC.Mk 2 BAe 125 C.Mk 1/2/3 Gazelle HT.Mk 3	Northolt
No. 47 Squadron	Hercules C.Mk 1/3	Lyneham
No 70 Squadron	Hercules C.Mk 1/3	Lyneham
TQF (1)	BAe 146 CC.Mk 2 Andover CC.Mk 2 (withdrawing 1990) Wessex HCC.Mk 4	Benson
Support helicopter squadrons:		
No. 7 Squadron	Chinook HC.Mk 1B	Odiham
No. 33 Squadron	Puma HC.Mk 1	Odiham
No. 72 Squadron	Wessex HC.Mk 2	Aldergrove
Calibration/radio relay squadron:		
No. 115 Squadron	Andover E.3/3A	Benson
Conversion units:		
No. 226 OCU	Jaguar GR.Mk 1A/T.Mk 2A	Lossiemouth
No. 233 OCU	Harrier GR.Mk 3/5/T.Mk 4/4A	Wittering
No. 240 OCU	Chinook HC.Mk 1B Puma HC.Mk 1	Odiham
No. 241 OCU	(VC10, BAe 146, TriStar on loan)	Brize Norton
No. 242 OCU	Hercules C.Mk 1/3	Lyneham
TTTE (2)	Tornado GR.Mk 1/GS/ GT/IS/IT	Cottesmore
TWCU (3)	Tornado GR.Mk 1	Honington
ATF (4)	(Andover on loan)	Benson

(1) The Queen's Flight
(2) Trinational Tornado Training Establishment
(3) Tornado Weapons Conversion Unit (No. 45 Reserve Squadron)
(4) Andover Training Flight

Tactical helicopter support for ground forces is provided the Aérospatiale/Westland Puma HC.Mk 1s of No. 33 Squadron, flying from Odiham in Hampshire.

Co-located with the Pumas and fulfilling a similar mission are No. 7 Sqn's Chinook HC.Mk 1s. The Chinooks are often used for lifting missions, carrying slung cargoes.

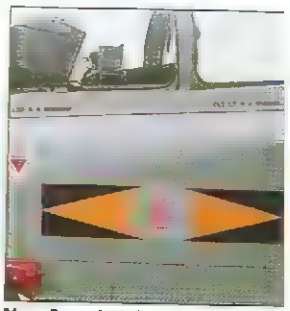
Aircraft of No. 32 Sqn at Northolt wear a stringed hunting horn badge.

The tiller badge of No. 115 Sqn emphasises the importance of navigation.

No. 72 Sqn's swift badge symbolises speed. It flies the Wessex HC.Mk 2!

Symbolising its bomber past, No. 216 Sqn has a suitable badge on its TriStars.

No. 5 Sqn had close ties in World War I with the Canadian Corps, hence the maple leaf.



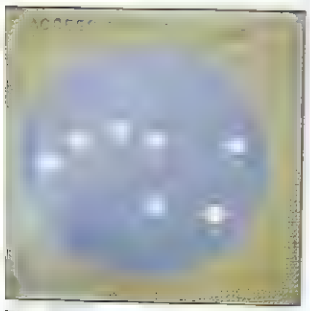
Nos 5 and 11 Sqns were the last RAF Lightning units. Now both fly the Tornado F.Mk 3.

No. 11 Group

Belated delivery in 1991 of an airborne early-warning system in the form of seven Boeing E-3D Sentry AEW.Mk 1s will replace four remaining Shackletons on 1 July 1991 and complete a wide-ranging re-equipment for the successor to Fighter Command. Of lower profile, but no less significant, are a dozen new, small, portable surveillance radars recently made operational to replace the vulnerable, large, fixed installations watching the UK shores. The I-UKADGE system of communications between fighter control stations has suffered delays in coming on stream and serious problems have also been experienced with planned installation of the JTIDS information distribution system for interceptors. The Tornado F.Mk 3's Foxhunter radar has been another victim of electronic difficulties, but is now well on the road to meeting its design specification.

No. 11 Group's HQ is at Stanmore, Middlesex, where an underground complex acts as reserve to the main RAF war direction centre at High Wycombe. The UK Air Defence Region (UKADR) is 750,000 square miles (1,943,000 km^2) extending almost to Iceland, within which all unidentified aircraft are intercepted by fighters maintained on constant Quick Reaction Alert (Interceptor). Sector 1, above latitude 55° N, is controlled by the Sector Operations Centre at Buchan, with a reserve at Boulmer. Sector 2 has Neatishead as primary SOC and Ash as secondary, all SOCs being underground.

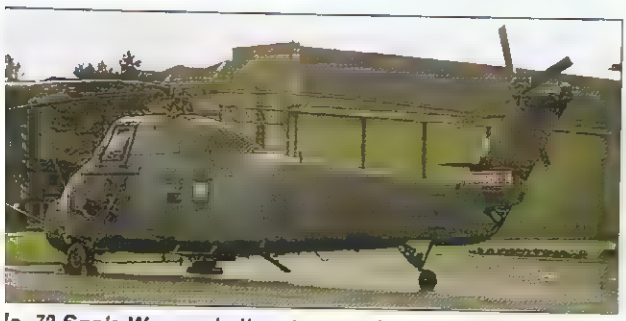
Eight squadrons, including the Coningsby OCU, are equipped with interceptor Tornados from 180 on order – the last, No. 111, due to become operational at the end of this year.



The 'Ursa Major' badge of No. 7 Sqn appropriately has seven stars.

No. 33 Sqn was the first RAF unit to fly the Hart bomber, the badge surviving today.

A large fleet of Hercules provides the RAF with its tactical transport needs. A few are configured as tankers while some have been stretched to C.Mk 3 standards. Most are C.Mk 1Ps, with refuelling probe and original short fuselage.



No. 72 Sqn's Wessex helicopters are fully committed to supporting the security forces in Northern Ireland, flying from Belfast's main airport at Aldergrove.

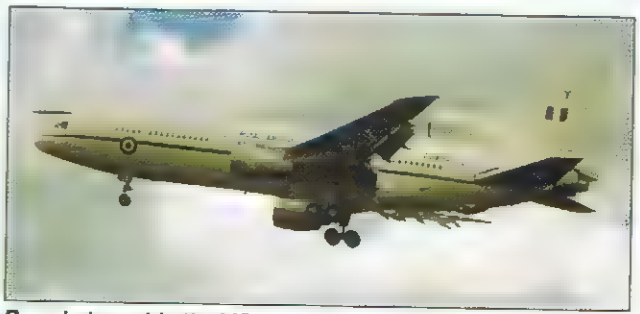
No. 101 Sqn's badge has a barret and the squadron's number.

No. 32 Sqn is the staff/VIP transport unit, unique in the RAF for operating three types of aircraft. This is an Andover CC.Mk 2, the largest aircraft on strength.

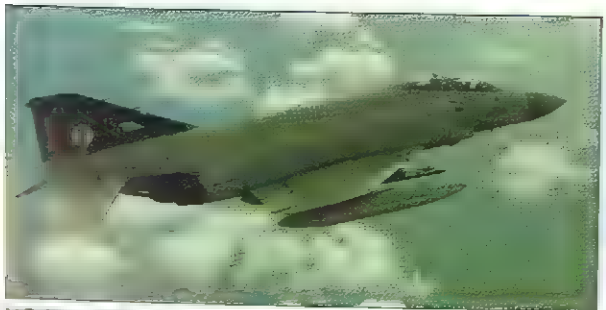
Calibration of navigation aids is the task of No. 115 Sqn. They fly suitably modified Andover E.Mk 3s from Benson in Oxfordshire.

Like the Luftwaffe and the RAF, the RAF supplies Tornados for the TTTE.

This BAe 125 of No. 32 Sqn has a low-visibility colour scheme and infra-red countermeasures fitted in the tail. The squadron also flies Gazelles on staff transport duties.



Based alongside the VC10s at Brize Norton, No. 216 Sqn's TriStars fulfil a dual tanker/transport role. The full tanker conversion has four hose/drogue units.



US Navy Phantoms were procured to equip No. 74 Sqn Wattisham, being designated F-4J(UK) in RAF service. The squadron has a tiger's head badge.

Partnering No. 74 Sqn on air defence duties from Wattisham are No. 56 Sqn, flying the Spey-engined Phantom FGR.Mk 2. This example is seen taxiing from the QRA alert shed.

No. 56 Sqn are known as the 'Firebirds', and carry their Phoenix badge on the fin.

Although most F.Mk 3s are permanently dedicated to SACEUR for day-to-day interception of unannounced visitors to the UKADR, Nos 11 and 29 Squadrons are committed to SACLANT for maritime air defence. In wartime, No. 11 would deploy to an advanced base at Brawdy or Stornoway, according to the threat direction.

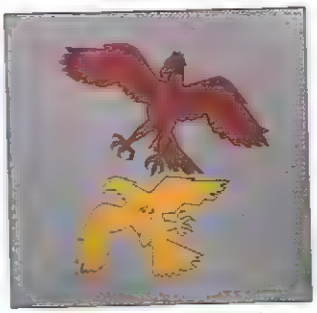
Like Tornados, McDonnell Douglas Phantom FGR.Mk 2s have four radar-guided Sky Flash and four heat-seeking AIM-9L Sidewinder missiles. Only No. 56 Squadron is home based with Mk 2s, co-located No. 74 having 14 ex-US Navy F-4J(UK)s sporting Sparrow in place of Sky Flash and standard GE J79 engines instead of the British Phantom's Rolls-Royce Speys. Nearly 90 Mk 2 Phantoms remain, whilst 30 FG.Mk 1s formerly based at Leuchars are in storage.

Two Tactical Weapons Units, comprising four Reserve Squadrons, have a peacetime training role, but would contribute 72 Sidewinder-armed Hawks (including some 'Red Arrows') to point defence or the Mixed Fighter Force in wartime. No. 85 Squadron is to reduce from six to two Bloodhound SAM sites shortly, leaving West Raynham and Wattisham operational beyond the end of the century. Regiment Rapier squadrons provide short-range defence for RAF stations not behind the Bloodhound belt, although Nos 19, 20 and 66 are unusual in being assigned to USAF bases with weapons bought by the United States.

No. 11 Group Units

UNIT	EQUIPMENT	BASE
(Supporting aircraft marks/types in parentheses)		
Interceptor squadrons (assigned to SACEUR):		
No. 5 Squadron	Tornado F.Mk 3	Coningsby
No. 23 Squadron	Tornado F.Mk 3	Leeming
No. 25 Squadron	Tornado F.Mk 3	Leeming
No. 43 Squadron	Tornado F.Mk 3	Leuchars
No. 56 Squadron	Phantom FGR.Mk 2	Wattisham
No. 64 Squadron – see No. 228 OCU		
No. 65 Squadron – see No. 229 OCU		
No. 74 Squadron	Phantom F-4J(UK)	Wattisham
No. 111 Squadron	Tornado F.Mk 3 – forming	Leuchars
Interceptor squadrons (assigned to SACLANT):		
No. 11 Squadron	Tornado F.Mk 3	Leeming
No. 29 Squadron	Tornado F.Mk 3	Coningsby
Point defence/mixed fighter force squadrons:		
No. 63 Squadron – see No. 2 TWU		
No. 79 Squadron – see No. 1 TWU		
No. 151 Squadron – see No. 2 TWU		
No. 234 Squadron – see No. 1 TWU		
Airborne early warning squadron:		
No. 8 Squadron	Shackleton AEW.Mk 2 (Chipmunk T.Mk 10)	Lossiemouth
Medium-range SAM squadron:		
No. 85 Squadron	Bloodhound Mk 2	'A' Flight: West Raynham 'B' Flight: North Coates 'C' Flight: Bawdsey 'D' Flight: Barkston Heath 'E' Flight: Wattisham 'F' Flight: Wyton
Short-range SAM squadrons (RAF Regiment):		
No. 19 Squadron	Rapier	Brize Norton (1)
No. 20 Squadron	Rapier	Honington (2)
No. 27 Squadron	Rapier	Leuchars
No. 46 Squadron	Rapier	Lossiemouth
No. 54 Squadron	Rapier	Leeming
No. 66 Squadron	Rapier	West Raynham (3)
Anti-aircraft artillery squadron (RAuxAF Regiment):		
No. 2729 Squadron	Oerlikon 35mm Skyguard	Waddington
Conversion units:		
No. 228 OCU	Phantom FGR.Mk 2	Leuchars
No. 229 OCU	Tornado F.Mk 3	Coningsby
Tactical Weapons Units:		
No. 1 TWU	Hawk T.Mk 1A	Brawdy
No. 2 TWU	Hawk T.Mk 1A	Chivenor

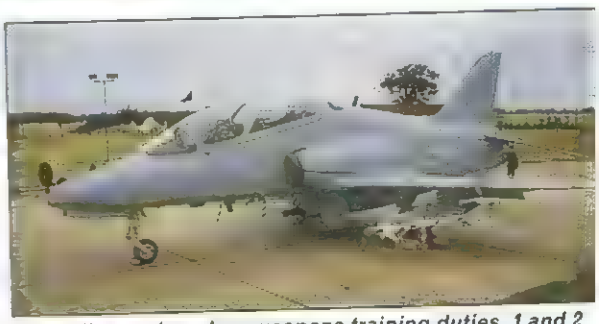
(1) Operational bases Upper Heyford and Fairford
(2) Operational bases Aconbury, Bentwaters and Woodbridge
(3) Operational bases Molesworth and Lakenheath



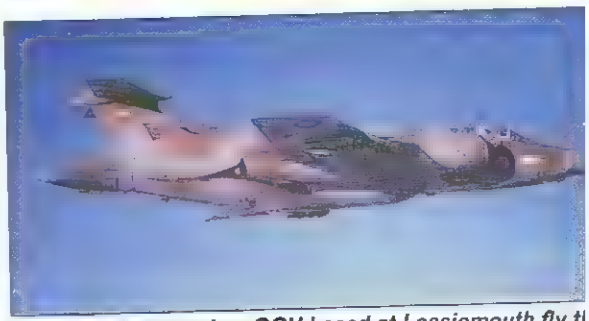
No. 29 Sqn's badge depicts an eagle vanquishing a buzzard in aerial combat.

No. 229 OCU Tornados wea the shadow squadron badg of No. 65 Sqn.

Until Sentry AEW.Mk 1s enter service, No. 8 Sqn struggles on with the piston-engined Shackleton AEW.Mk 2, only fo aircraft left to provide AEW coverage for the UKADR.



Normally employed on weapons training duties, 1 and 2 TWU Hawk T.Mk 1As wear air defence grey schemes and carry Sidewinder missiles for emergency air defence.

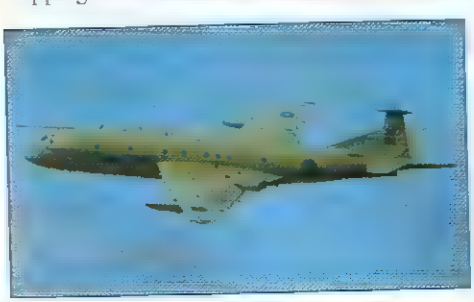


Two squadrons and an OCU based at Lossiemouth fly t Buccaneer S.Mk 2 on anti-ship strikes. This aircraft is fr No. 208 Sqn.

Among the Canberras based at Wyton are the T.Mk 17s No. 360 Sqn, which provide ECM training for UK air defences. The squadron has some Royal Navy staff.

No. 18 Group

The RAF's maritime group is No. 18, which is jointly located with the Navy's Fleet HQ underground at Northwood, Middlesex. AOC No. 18 Group has the dual NATO appointments of Commander Maritime Air Eastern Atlantic and COMAIR Channel. For maritime reconnaissance, 34 BAe Nimrod MR.Mk 2s operate over the Atlantic tracking Warsaw Pact shipping and submarine movements. A further round of equipment updating for these jet-powered patrollers has been rejected because of a reduced expectation of remaining airframe life, although they will continue in service until at least the end of the century. Weapons include the depth charge version of WE177 nuclear device and Stingray homing torpedoes. Three special Nimrods fly with No. 51 Sqn for strategic reconnaissance purposes.



Only 34 Nimrods MR.Mk 2s operate within No. 18 Group, yet they provide all of the RAF's maritime surveillance capabilities.

Lossiemouth's Buccaneer force is assigned to SACLANT for anti-shipping strike operations in the Iceland-UK gap. In February 1990, BAe completed the 42nd and last Buccaneer upgrade with FIN1063 inertial navigation equipment and improved defensive aids. The aircraft have recently gained the ability to carry four BAe Sea Eagle long-range anti-ship missiles to augment longer-term armament such as WE177 bombs, Matra AS.37 Martel anti-radar missiles and laser-guided bombs.

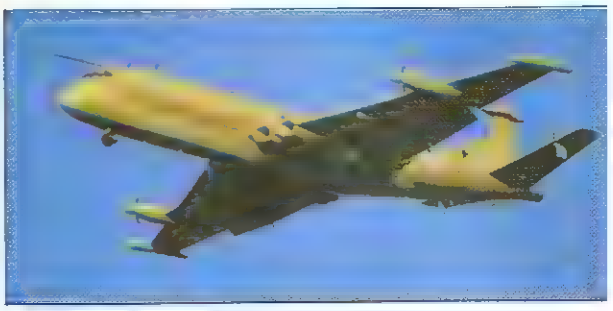
Canberras are in No. 18 Group because of their role of visual maritime reconnaissance in an immediate pre-conflict situation. No. 360's dozen T.Mk 17s give radar operators on land, sea and air the opportunity to practise their art in the face of electronic jamming, whilst No.

100's 19 aircraft are used for towing several types of target. Six remaining Canberra PR.Mk 9s of No. 1 Photo Reconnaissance Unit have mainly non-operational survey tasks to perform. The SAR helicopter fleet comprises 19 each of Sea Kings and Wessex located around the coast – officially to rescue downed aircrew, although 95 per cent of their missions are for the civilian population.

No. 18 Group Units

UNIT	EQUIPMENT	BASE
(Supporting aircraft marks/types in parentheses)		
Maritime strike/attack squadrons:		
No. 12 Squadron	Buccaneer S.Mk 2B (Hunter T.Mk 7/8)	Lossiemouth
No. 208 Squadron	Buccaneer S.Mk 2B (Hunter T.Mk 7/8)	Lossiemouth
Maritime reconnaissance squadrons:		
No. 38 Squadron – see No. 236 OCU		
No. 42 Squadron	Nimrod MR.Mk 2/2P	St Mawgan
No. 120 Squadron	Nimrod MR.Mk 2/2P	Kinloss
No. 201 Squadron	Nimrod MR.Mk 2/2P	Kinloss
No. 206 Squadron	Nimrod MR.Mk 2/2P	Kinloss
Strategic reconnaissance (Sigint) squadron:		
No. 51 Squadron	Nimrod R.Mk 1P	Wyton
Photo-reconnaissance unit:		
No. 1 PRU	Canberra PR.Mk 9	Wyton
Search and rescue squadrons:		
No. 22 Squadron	Wessex HC.Mk 2	HQ: Finningley 'A' Flight: Chivenor 'B' Flight: Leuchars 'C' Flight: Valley 'E' Flight: Coltishall
No. 202 Squadron	Sea King HAR.Mk 3	HQ: Finningley 'A' Flight: Boulmer 'B' Flight: Brawdy 'C' Flight: Manston 'D' Flight: Lossiemouth 'E' Flight: Leconfield
Target facilities squadrons:		
No. 100 Squadron	Canberra B.Mk 2/ PR.Mk 7/E.Mk 15/ TT.Mk 18	Wyton
No. 360 Squadron	Canberra T.Mk 17/17A	Wyton
Conversion and training units:		
No. 231 OCU	Canberra B.Mk 2/ T.Mk 4	Wyton
No. 236 OCU	Nimrod MR.Mk 2/2P	St Mawgan
No. 237 OCU	Buccaneer S.Mk 2B (Mk 2A) (Hunter T.Mk 7/7A/8B)	Lossiemouth
SARTF (1)	Wessex HC.Mk 2	Valley
SKTF (2)	Sea King HAR.Mk 3	RNAS Culdrose

(1) Search And Rescue Training Flight
(2) Sea King Training Flight



Three Nimrod R.Mk 1Ps operate with No. 51 Sqn at Wyton, employed on clandestine electronic surveillance missions. They are regularly deployed to overseas bases.

High altitude photo-reconnaissance/survey capability is provided by the Canberra PR.Mk 9s of No. 1 Photographic Reconnaissance Unit, based at Wyton.

Direct-reporting units

Units outside Europe report directly to Strike Command, as do some trials organisations such as the OEUs responsible for determining operational procedures and evaluating new weapons and equipment. The Falklands garrison includes four Phantoms, a couple of Hercules tankers, two Chinooks and two Sea Kings and, to dissuade Guatemalan claims to part of Belize, four Pumas and the last four operational Harrier GR.Mk 3s are stationed in Central America. Five ex-Navy Wessex HC.Mk 5Cs provide SAR services for the Armament Practice Camp at Akrotiri, Cyprus, but now only occasionally fly on UN-related duties associated with partitioning of the island into Greek and Turkish areas. Eight Wessex in Hong Kong are used for general support (even, as on Cyprus, fire-fighting) including the thankless task of helping Gurkha patrols to catch illegal immigrants.

Direct-reporting units

UNIT	EQUIPMENT	BASE	ROLE
No. 28 Squadron	Wessex HC.Mk 2	Sek Kong, HK	SAR/support
No. 78 Squadron	Sea King HAR.Mk 3 Chinook HC.Mk 1B	Mount Pleasant, F	SAR/support
No. 84 Squadron	Wessex HC.Mk 5C	Akrotiri, Cyprus	SAR/support
No. 1312 Flight	Hercules C.Mk 1K	Mount Pleasant, F	Tanker, mari me recce
No. 1345 Flight	Phantom FGR.Mk 2	Mount Pleasant, FI	Air defence
No. 1417 Flight	Harrier GR.Mk 3	Belize City IAP	Close support
No. 1563 Flight	Puma HC.Mk 1	Belize City IAP	SAR/support
EWAU (1)	(Andover E.3 loaned)	Wyton	Trials
SAOEU (2)	Tornado GR.Mk 1/A Harrier GR.Mk 5/7, T.Mk 4 Jaguar T.Mk 2A	Boscombe Down	Trials
F3 OEU (3)	Tornado F.Mk 3	Coningsby	Trials
IAM (4)	Hunter T.Mk 7 Jaguar T.Mk 2A	Farnborough	Trials

(1) Electronic Warfare Avionic Unit
(2) Strike Attack Operational Evaluation Unit
(3) Tornado F.Mk 3 Operational Evaluation Unit
(4) RAF Institute of Aviation Medicine

Characterised by prominent white stripes, the Wessex HC.Mk 2s of No. 28 Sqn fly general transport duties aroun the colony of Hong Kong.

The Strike Attack Operational Evaluation Unit has a Harrier T.Mk 4.

The Tornado F.Mk 3 OEU wears a similar badge to t SAOEU.

RAF GERMANY

Successor to the occupation air force established in West Germany after World War II, RAFG (HQ: Rheindahlen) is a partner with the British Army of the Rhine in the UK's 'up front' contribution to European security. Traditionally, the C-in-C has the wartime NATO position of commander, 2nd Allied Tactical Air Force, in which RAFG is a partner with the Belgian and Netherlands air forces, most northern-based units of the Luftwaffe and resident and reinforcement USAF squadrons. TWOATAF represents half of Allied Air Forces Central Europe (AAFCE) and, where appropriate, works in support of Northern Army Group. Apart from its flying stations, RAFG administers the Nordhorn weapons range and provides a Support Unit at the Decimomannu air combat training base in Sardinia.

All bar one of the 14 RAFG squadrons have an operational role, representing 35 per cent of RAF front-line aircraft and 20 per cent of TWOATAF's in-theatre forces. Eight Tornado units have 110 of the 228 production GR.Mk 1s (including 50 dual control) procured for the RAF, their weapons including tactical versions

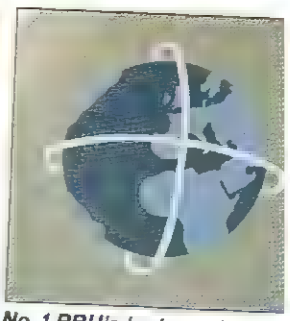
Based at Boscombe Down, the SAOEU is responsible for the development and testing of strike equipment. Tornad and Harriers are on strength.

No. 12 Sqn's badge is a reminder that the squadron flew the Fairey Fox.

No. 100 Sqn's skull and crossbones badge dates back to World War I.

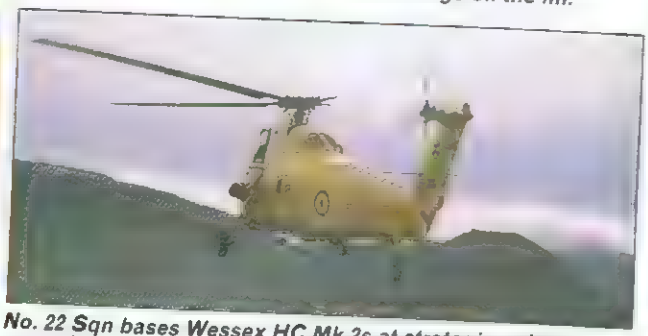
Canberra T.Mk 17s of No. 360 Sqn carry the unit's Druse Moth badge on the fin.

Rarely seen is the badge of secretive No. 51 Sqn, a flying goose.



No. 1 PRU's badge suitably circumnavigates the globe, the unit often flying overseas

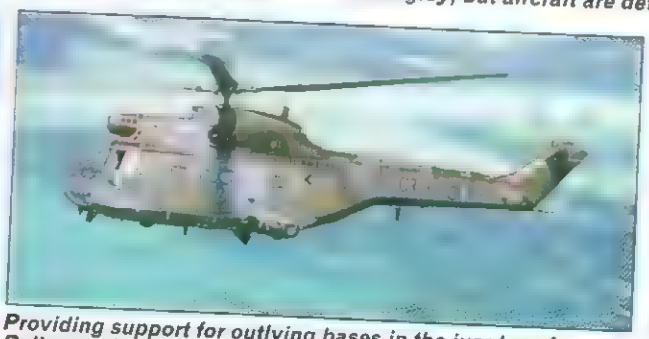
The 'Pi' symbol of No. 22 Sqn's badge denotes the number's definition (i.e. 22/7).



No. 22 Sqn bases Wessex HC.Mk 2s at strategic points around the coastline for search and rescue. This example from Valley is practising in the mountains of Snowdonia.

Partnering Wessex on the SAR tasking are No. 202 Sqn Sea King HAR.Mk 3s. The squadron headquarters is at Finningley, but aircraft are detached to five other bases.

Royal Navy Wessex HC.Mk 5Cs are flown by No. 84 Sqn, providing utility transport on the island of Cyprus. A blue identification stripe is worn.



Providing support for outlying bases in the jungles of Belize are Puma HC.Mk 1s of No. 1563 Flight, normally based at Belize City International Airport.

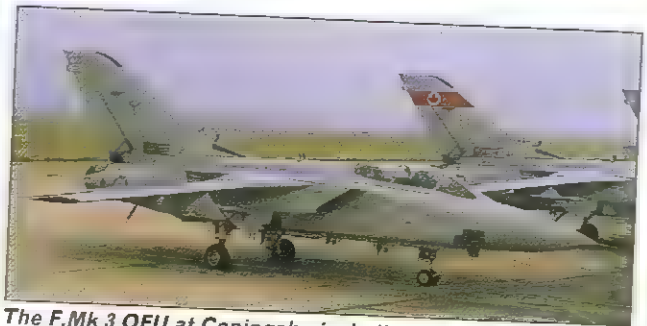
The four Harrier GR.Mk 3s of No. 1417 Flight wear a swordfish insignia.

84 Sqn aircraft wear nia from playing cards.

No. 1417 Flt's Harrier GR.Mk 3s are based in Belize as a counter to Guatemalan ambitions towards the Central American state.

No. 1312 Flt at Mount Pleasant provides Hercules for transport and tanker support for the UK garrison. Wingtip ESM pods provide a measure of surveillance capability.

umas of No. 1563 Flight his snake badge in r of the Belize jungle.



The F.Mk 3 OEU at Coningsby is dedicated to evaluating tactics and equipment for the new and growing Tornado F.Mk 3 force. Two or three aircraft are assigned at any given time.

Helicopter support in the Falklands is provided by No. 78 Squadron, which flies both the Sea King HAR.Mk 3 (illustrated) and the Chinook HC.Mk 1.

of WE177, the JP233 anti-airfield bomblet dispenser, 1,000lb (454kg) retarded bomb and BL755 cluster bomb. Nos 16 and 20 Squadrons have CPU-123B Paveway laser-guided bombs, for which the Buccaneers of No. 237 OCU (No. 18 Group) would provide designation services in wartime with their AVQ-23E Pave Spike pods.

The search continues for a stand-off replacement for BL755, but belated service-entry of the BAe Alarm anti-radar missile is on hand in No. 9 Squadron, which is also expected to receive up to a dozen TIALD (thermal imaging and laser-designation) pods for its 'pathfinder' role.

The three other Brüggen squadrons are primarily dedicated to nuclear strike, whilst No. 2 at Laarbruch is assigned to reconnaissance with the Vinten (ex-BAe) 4000 IR linescan system. An order will shortly be placed for 26 Tornado GR.Mk 4s, to which standard existing aircraft will be converted in the 1990s, with GEC Spartan terrain-referenced navigation, a new ESM suite, night vision equipment, upgraded engines and other improvements.

The unique Harrier force has been rejuvenated by continuing deliveries to the RAF of 96 aircraft, all of which will eventually be to GR.Mk 7 configuration with night vision equipment. Armed with retarded bombs and BL755 CBUs, the aircraft will be partnered by 14 two-seat Harrier T.Mk 10s which have recently been ordered – mainly for the Wittering OCU.

Since receiving Harrier IIs, the two squadrons have seen their role angled away from close air support towards longer-range battlefield air interdiction, although they continue to provide a rapid-reaction service when the army calls for firepower. Two Phantom squadrons work with the USAF in policing the Air Defence Identification Zone which runs parallel to the East German border, the task made necessary by treaty restrictions which prevent the Luftwaffe from so doing. The Phantoms are armed similarly to those in the UK, except that an SUU-23/A cannon pod is normally carried on the centreline, whereas home-based FGR.Mk 2s fit an extra tank in that position when on QRA(I).

Unarmed aircraft include the Chinooks and Pumas of the Support Helicopter Force which, like the Harriers, would fly from dispersed sites in wartime. They are dedicated to logistic support of 1 (British) Corps in missions such as moving field guns and ammunition or transporting rapid-reaction troops to deal with Spetsnaz infiltration. No. 60 Squadron has Andovers for communications and light transport (including medical evacuation to the UK), but one of its aircraft is an Andover R.Mk 4 replacement for the RAF's last pair of Pembroke C(PR).Mk 1s. The cameras are used when flying in the air corridors to Berlin. Over the city itself, two Chipmunks of Gatow Station Flight exercise the UK's right to fly anywhere within the Berlin Control Zone.

Royal Air Force Germany Units

UNIT	EQUIPMENT	BASE
Interdictor/strike squadrons:		
No. 14 Squadron	Tornado GR.Mk 1	Brüggen
No. 17 Squadron	Tornado GR.Mk 1	Brüggen
No. 31 Squadron	Tornado GR.Mk 1	Brüggen
Interdictor/attack squadrons:		
No. 15 Squadron	Tornado GR.Mk 1	Laarbruch
No. 16 Squadron	Tornado GR.Mk 1	Laarbruch
No. 20 Squadron	Tornado GR.Mk 1	Laarbruch
Defence suppression squadron:		
No. 9 Squadron	Tornado GR.Mk 1	Brüggen
Air defence squadrons:		
No. 19 Squadron	Phantom FGR.Mk 2	Wildenrath
No. 92 Squadron	Phantom FGR.Mk 2	Wildenrath
Short-range SAM squadrons (RAF Regiment):		
No. 16 Squadron	Rapier	Wildenrath
No. 26 Squadron	Rapier	Laarbruch
No. 37 Squadron	Rapier	Brüggen
No. 63 Squadron	Rapier	Gütersloh
Reconnaissance (secondary attack) squadron:		
No. 2 Squadron	Tornado GR.Mk 1A	Laarbruch
Battlefield air interdiction/CAS squadrons:		
No. 3 Squadron	Harrier GR.Mk 5	Gütersloh
No. 4 Squadron	Harrier GR.Mk 7 – converting	Gütersloh
Support helicopter squadrons:		
No. 18 Squadron	Chinook HC.Mk 1B	Gütersloh
No. 230 Squadron	Puma HC.Mk 1	Gütersloh
Transport squadron:		
No. 60 Squadron	Andover C.Mk 1/CC.Mk 2/R.Mk 4	Wildenrath
Station flights:		
Berlin SF	Chipmunk T.Mk 10	Gatow
Gütersloh SF	Harrier T.Mk 4	Gütersloh

Two squadrons of Phantom FGR.Mk 2s provide air defen cover for the 2nd ATAF area from the base at Wildenrath. This aircraft is from No. 19 Sqn.

No. 92 Sqn is the partners of No. 19 in the air defence rol usually carrying a centreline gun pod. Policing the ADIZ its principal role.

No. 19's dolphin badge stems from the squadron's use of the Sopwith Dolphin.

The cobra on No. 92's ba signifies that the unit wa East India 'gift' squadro

Rapid mobility for ground forces is especially importar Germany. No. 18 Sqn flies Chinook HC.Mk 1s to provid facility.

Just as in Strike Command, the Chinooks are partnere Pumas, in this case No. 230 Sqn. Both helicopter units from Gütersloh.

SUPPORT COMMAND

All flying training apart from OCUs and TWUs, and all technical support and maintenance, is the responsibility of Support Command (HQ: Brampton). Responsibility for staffing the RAF can begin even before formal entry, as the associated HQ Air Cadets at Newton has a fleet of 49 DHC Chipmunks, one BAe Bulldog, 94 Grob Viking sailplanes and 53 Grob Vigilant (replacing 40 Slingsby Venture) motor-gliders based around the country to provide flying for the Air Training Corps and Combined Cadet Force. University Air Squadrons have many of the RAF's 118 Bulldogs to provide pre-entry training.

Once in uniform, student pilots are increasingly being instructed on the Shorts Tucano, of which 130 are replacing Jet Provosts, beginning at Church Fenton in December 1989. However, those joining without UAS or civilian flying experience first receive 63 hours in the air with Swinderby's Chipmunks. Future fast-jet pilots follow Tucano or JP with the Hawk course at Valley before learning weapons delivery techniques at one of the two TWUs of No. 11 Group and progressing from there to the appropriate OCU for their first squadron posting. Those selected for multi-engine aircraft or helicopters leave the Tucano or JP some hours before their compatriots, and go to No. 6 FTS to fly Jetstreams or No. 2 FTS for the Gazelle and Wessex course.

No. 3 Sqn is the first RAF Germany squadron to receive the updated Harrier GR.Mk 5. These are based at Gütersloh, NATO's most easterly air base in Germany.

No. 3 Sqn's badge has a cockatrice upon a monolith, representing Stonehenge.

No. 230 Sqn (Puma) has a tiger badge, symbolising past service in Malaya.

Previously operating Pembrokes, No. 60 Sqn now flies Andovers in the communications/staff transport role. One has cameras fitted (R.Mk 4) for reconnaissance capability.

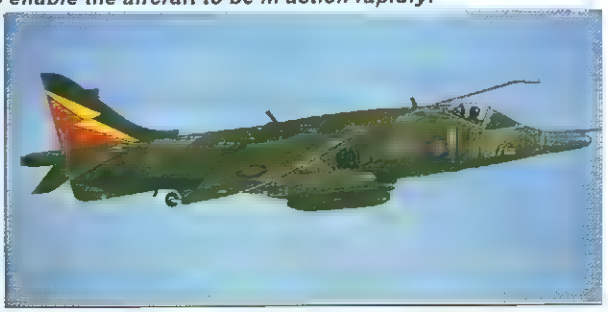
RAF and AAC bases in West Germany

RAF forces in Germany are assigned to the northern half of the country as part of 2nd ATAF. They are based close to the Dutch border to be as far away as possible from the East German border to avoid surprise attack. Gütersloh (Harriers and helicopters) and army bases are much closer, to enable the aircraft to be in action rapidly.

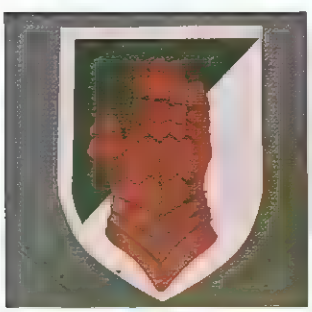
No. 14 Sqn's winged St. George Cross comes from Palestine.

No. 15 Sqn simply has the squadron numeral in Roman on the fin.

Cross-keys denote No. 16 Sqn's close association with the army.

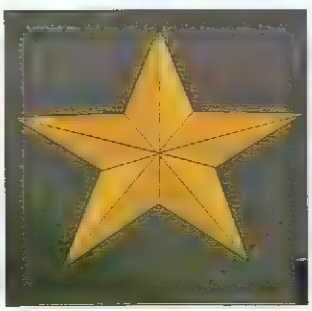


Both RAFG Harrier squadrons flew the GR.Mk 3, but No. 3 has equipped with the GR.Mk 5 and No. 4 is getting the GR.Mk 7. This is one of the latter's GR.Mk 3s.

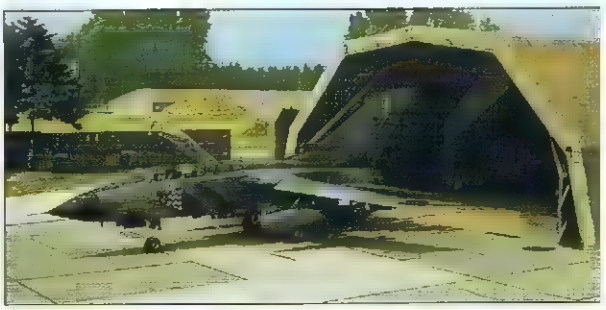


The gauntlet badge of No. 17 Sqn was awarded when the unit flew the fighter of the same name.

No. 20 Sqn now flies Tornados in Germany. In the past it had long connections with the Far East.



No. 31 Sqn flies Tornado GR.Mk 1s as part of the Brüggen wing. The star emblem adorns the fin.



RAFG warplanes are housed in hardened aircraft shelters, as used by this No. 17 Sqn Tornado. The squadron is one four based at Brüggen.

Navigators, Air Engineers (AE) and Air Electronics Officers (AEO) also report to No. 6 FTS, the first-mentioned flying in Bulldogs, Dominies and (if they are destined to go in the back of a fast jet) Jet Provosts. AEs and AEOs only sample the Dominie, but the JP will be replaced in 1992 by a combination of Tucano and Hawk. All types of trainer are flown by the Central Flying School, which is responsible for producing instructors, whilst the RNEFTS is RAF-administered, yet gives elementary flying on Bulldogs to future naval aviators. Church Fenton's Refresher Flying Flight (one of the last to convert from JPs to Tucanos) is for the benefit of officers returning to the air after a desk-posting.

Maintenance and related training duties managed by Support Command include major overhaul and conversion centres at Abingdon and St Athan; a storage unit at Shawbury; and Schools of Technical Training at Halton and Cosford, which will shortly combine at the latter location.

Support Command Units

UNIT	EQUIPMENT	BASE
CFS (1)	Jet Provost T.3A/5A Bulldog T.Mk 1 Tucano T.Mk 1 Chipmunk T.Mk 10	Scampton (Relief: Sturgate)
	Hawk T.Mk 1/1A 'Red Arrows'	Scampton
	Hawk T.Mk 1	Valley
	Gazelle HT.Mk 3	Shawbury
	Viking T.1/Vigilant T.1	Syerston
EFTS (2)	Chipmunk T.Mk 10	Swinderby
1 FTS	Jet Provost T.Mk 3A /5A	Linton-on-Ouse (Relief: Dishforth)
	(3) Bulldog T. Mk 1	Detached: Topcliffe
2 FTS	Gazelle HT.Mk 3 (HT.Mk 2) Wessex HC.Mk 2	Shawbury (Relefs: Chetwynd, Ternhill)
3 FTS	Jet Provost T.Mk 5A	Cranwell (Relief: Barkston Heath)
4 FTS	Hawk T.Mk 1	Valley (Relief: Mona)
6 FTS	Dominie T.Mk 1 Jet Provost T.Mk 5/5B (4) Jetstream T.Mk 1	Finningley (Relief: Lindholme)
7 FTS	Tucano T.Mk 1 (5) Jet Provost T.Mk 5A	Church Fenton (Relief: Elvington)

University Air Squadrons:

Aberdeen, Dundee & St Andrews UAS	Bulldog T.Mk 1	Leuchars
Birmingham UAS	Bulldog T.Mk 1	Cosford
Bristol UAS	Bulldog T.Mk 1	Filton
Cambridge UAS	Bulldog T.Mk 1	Teversham
East Lowlands UAS	Bulldog T.Mk 1	Turnhouse
East Midlands UAS	Bulldog T.Mk 1	Newton
Glasgow & Strathclyde UAS	Bulldog T.Mk 1	Abbotsinch
Liverpool UAS	Bulldog T.Mk 1	Woodvale
London UAS	Bulldog T.Mk 1	Abingdon
Manchester UAS	Bulldog T.Mk 1	Woodvale
Northumbrian UAS	Bulldog T.Mk 1	Leeming
Oxford UAS	Bulldog T.Mk 1	Abingdon
Queens UAS	Bulldog T.Mk 1	Sydenham
Southampton UAS	Bulldog T.Mk 1	Lee-on-Solent
Wales UAS	Bulldog T.Mk 1	St Athan
Yorkshire UAS	Bulldog T.Mk 1	Finningley

Air Experience Flights:

1 AEF	Chipmunk T.Mk 10	Manston
2 AEF	Chipmunk T.Mk 10	Hurn
3 AEF	Chipmunk T.Mk 10	Filton
4 AEF	Chipmunk T.Mk 10	Exeter
5 AEF	Chipmunk T.Mk 10	Teversham
6 AEF	Chipmunk T.Mk 10	Abingdon
7 AEF	Chipmunk T.Mk 10	Newton
8 AEF	Chipmunk T.Mk 10	Shawbury
9 AEF	Chipmunk T.Mk 10	Finningley
10 AEF	Chipmunk T.Mk 10	Woodvale
11 AEF	Chipmunk T.Mk 10	Leeming
12 AEF	Chipmunk T.Mk 10	Turnhouse
13 AEF	Bulldog T.Mk 1	Sydenham

Volunteer Gliding Schools (winch-launching):

611 VGS	Viking T.Mk 1	Swanton Morley
614 VGS	Viking T.Mk 1	Wethersfield
615 VGS	Viking T.Mk 1	Kenley
617 VGS	Viking T.Mk 1	Manston
618 VGS	Viking T.Mk 1	West Malling
621 VGS	Viking T.Mk 1	Weston-super-Mare
622 VGS	Viking T.Mk 1	Upavon
625 VGS	Viking T.Mk 1	South Cerney
626 VGS	Viking T.Mk 1	Predannack
631 VGS	Viking T.Mk 1	Sealand
634 VGS	Viking T.Mk 1	St Athan
636 VGS	Viking T.Mk 1	Swansea
643 VGS	Viking T.Mk 1	Scampton
645 VGS	Viking T.Mk 1	Catterick
661 VGS	Viking T.Mk 1	Kirknewton
662 VGS	Viking T.Mk 1	Arbroath

(above correct to May 1990)

Volunteer Gliding Schools (self-launching):

612 VGS	Vigilant T.Mk 1	Benson
613 VGS	Vigilant T.Mk 1	Halton
616 VGS	Vigilant T.Mk 1	Henlow
624 VGS	Vigilant T.Mk 1	Chivenor
632 VGS	Vigilant T.Mk 1	Ternhill
633 VGS	Vigilant T.Mk 1	Cosford
635 VGS	Vigilant T.Mk 1	Samlesbury
637 VGS	Vigilant T.Mk 1	Little Rissington
642 VGS	Vigilant T.Mk 1	Linton-on-Ouse
644 VGS	Vigilant T.Mk 1	Syerston
663 VGS	Vigilant T.Mk 1	Kinloss
664 VGS	Vigilant T.Mk 1	Bishop's Court

(above schools converting from Venture T.Mk 1, May-December 1990)

Air Cadets' Central Gliding School:

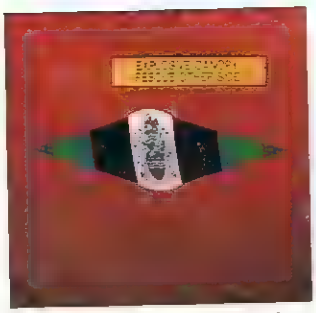
ACCGS	Vigilant T.Mk 1, Viking T.Mk 1 Valiant T.Mk 1, Janus C	Syerston

Display teams:

Red Arrows – see CFS

BBMF (6)	Lancaster B.Mk I Spitfire IIa/Vb/XIV/XIX Hurricane Mk IIc Devon C.Mk 2 Chipmunk T.Mk 10	Coningsby
VDF (7)	Vulcan B.Mk 2	Waddington

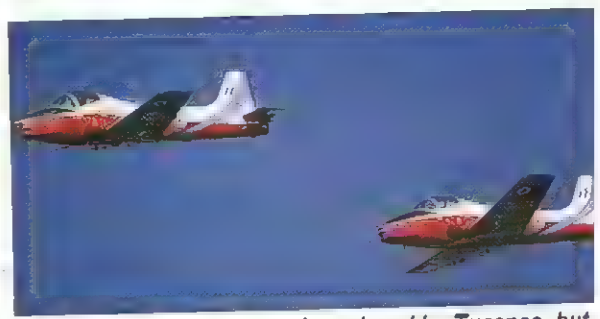
(1) Central Flying School
(2) Elementary Flying Training School
(3) Royal Navy Elementary Flying Training School
(4) Multi-Engined Training Squadron
(5) Refresher Flying Flight
(6) Battle of Britain Memorial Flight
(7) Vulcan Display Flight



The Central Flying School trains instructors. Its badge is seen here on a JP.

The EFTS is based at Swinderby, using Chipmunks.

Support Command's most potent aircraft is the BAe Haw used for advanced training with No. 4 FTS at Valley. This smart scheme is being slowly adopted.

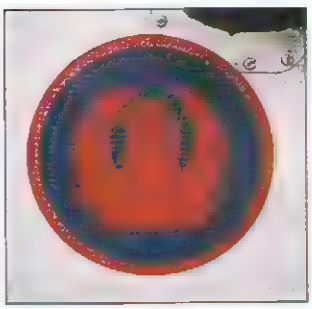


Jet Provosts are being slowly replaced by Tucanos, but still provide the bulk of the RAF trainer fleet. These T.Mk fly with No. 3 FTS/RAF College at Cranwell.

Navigation training is provided by No. 6 FTS at Finningl with Dominie T.Mk 1s (illustrated), Bulldogs and Jet Provosts. Dominies are also used to train engineers.

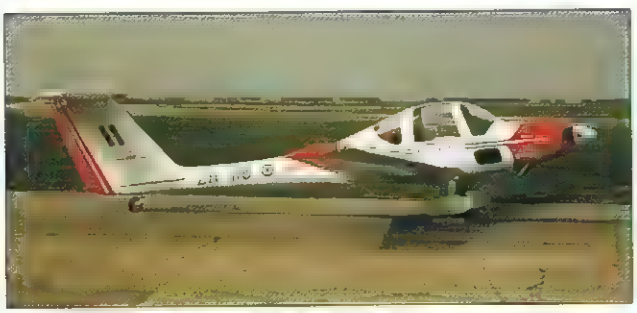
Also with No. 6 FTS at Finningley are the RAF's Jetstre T.Mk 1 trainers. These are used for multi-engine trainin pilots destined for tankers and transports.

No. 4 FTS Hawks wear this badge on the fin, denoting strong ties with Egypt.



Badge of No. 6 FTS, carried by the unit's Bulldogs and Jet Provosts.

After many years of sterling service with RAF Support Command, the BAC Jet Provost is giving way to the Short Tuc T.Mk 1, the turboprop engine giving far better reliability and economy, while the tandem seating arrangement is bette suited for fast-jet training. The rear cockpit is raised considerably to give the instructor an excellent view forwards.



Twelve Volunteer Gliding Schools are giving up their Slingsby Venture motor-gliders in favour of Grob Vigilants. Unpowered VGS units fly the Grob Viking.

Air Experience Flights carry their own badges, this being No. 6 from Abingdon.

The venerable Chipmunk T.Mk 10 is used by all but one the AEFs, mainly to provide flying experience for Air Training Corps members. This is from No. 11 AEF.

Bulldog T.Mk 1s are the main equipment of the University Air Squadrons, providing flying training for undergraduates. These aircraft are from London UAS.

No. 2 FTS is based at Shawbury. The unit flies the Gazelle HT.Mk 2 (illustrated) and Wessex HC.Mk 2 helicopters to train all prospective RAF rotary-wing pilots.

The best-known Support Command (and best-known RAF) unit is the Red Arrows, th service's official aerobatic display team. In wartime the Hawk T.Mk 1As would don gr camouflage and Sidewinder missiles and become emergency fighters.

Fleet Air Arm

From headquarters at Yeovilton, the Flag Officer Naval Aviation administers the Royal Navy's aviation element, the FAA. Current strength is some 340 aircraft, of which just over 100 are fixed-wing, including 39 Sea Harriers. The RN's prime NATO role is anti-submarine patrol in the North Atlantic and Home Waters, but it continues to sail the world's oceans to a more limited extent than was formerly possible, taking FAA aircraft with it. Of 62,600 personnel in RN service, 2,200 are directly involved with naval aviation – representing a sharp fall from the average of 3,400 maintained during the second half of the 1980s.

Having no 'full-size' aircraft-carriers, the RN operates three 19,500 ton (19813 tonne) ASW carriers, HMS *Invincible*, *Illustrious* and *Ark Royal*, each built to accommodate five BAe Sea Harriers and 10 Sea Kings. They are now being modified with bow ramps angled at 12° (only *Ark Royal* was built as such) and accommodation for an extra three Sea Harriers, while two AEW Sea Kings are included in a proportionately reduced helicopter complement.

In wartime, each vessel would accommodate 12 Sea Harriers, five ASW and three AEW Sea Kings. Two carriers are normally in commission, the current pair being *Ark Royal* and *Invincible* – the latter having replaced *Illustrious* in May 1989, after refit.

All survivors of the 57 Harrier FRS.Mk 1s built are being upgraded to Mk 2 standard with look-down Blue Vixen radar and shoot-down AIM-120 AMRAAM missiles. Sea Eagle missiles give an anti-ship capability, and WE177 nuclear bombs can be carried. Other weapons include AIM-9L Sidewinder, 1,000lb (454kg) bombs and 68-mm rocket pods. A further 10 new-build Mk 2s have been ordered, but it is unlikely that they will be used to form the long-promised No. 802 Squadron. Carrier deployments are maintained by Nos 800 and 801 Squadrons, with No. 899 acting as 'headquarters' (training) squadron, making only brief excursions afloat. Also with No. 899 are two Harrier T.Mk 4Ns and three T.Mk 4As (two ex-RAF) used for pilot's airframe conversion, and a pair of Hunter T.Mk 8Ms fitted with the earlier Blue Fox radar to complete the instructional syllabus.

The Westland/Sikorsky Sea King is the FAA's primary anti-submarine helicopter for carrier and other medium-sized ship deployments, although trials recently have taken place aboard vessels usually operating one or two Lynx. Currently in service are some 70 Sea King HAS variants, several of which began their lives as Mk 1s and have been progressively upgraded.

The common standard is now Mk 5, but conversion to Mk 6 is well under way, augmented by four new helicopters of this mark, recently delivered. Improvements in the latest model include more advanced 'dipping' sonar and upgraded ESM equipment, plus a new type of MAD that can operate inside the aircraft. Standard armament is the Stingray homing torpedo, the Mk 6 introducing the ability to fire Sea Eagle missiles.

Mk 5 and Mk 6 Sea King HAS.Mk 5/6 squadrons, No. 706 is a second line unit (as indicated by its 700-series number) for training. Two of the other squadrons are assigned to the carrier force with nine helicopters each, while Prestwick-based No. 819 Squadron defends and supports the nuclear submarine bases of the Clyde Estuary.

Sea Kings are occasionally deployed aboard tankers and supply ships of the Royal Fleet Auxiliary, including the training ship RFA *Argus*, which can accommodate up to six. Replacement for the Sea King is in prospect by the EHI EH-101 Merlin, 50 of which are on order to be delivered from the mid-1990s onwards.

Ten further Sea Kings have been converted to AEW.Mk 2A standard with a distinctive external housing for Searchwater radar. Produced with speed during the Falklands War, this variant now serves aboard carriers in pairs detached from No. 849 Squadron. Four former HAS.Mk 5s have been converted to HAR.Mk 5s by removal of anti-submarine equipment. They operate with No. 771 Squadron at Culdrose in fleet support and SAR roles.

More suited to such operations, the FAA's 34 Sea King HC.Mk 4s are equivalents of the export Westland Commando, able to carry 27 armed Marines, or 6,000lb (2722kg) internally or an 8,000lb (3628kg) underslung load. Nos 845 and 846 Squadrons can be embarked aboard the assault ships HMS *Fearless* and *Intrepid*. Training for air and maintenance crews is provided by No. 707 Squadron, the former teaching mountain flying, deck landing and low-level navigation, amongst other skills. No. 772 Squadron is a support/SAR unit with duties including vertrep (vertical replenishment) of ships training in the Channel.

Since retirement of the Wasp in 1988, all small ships' flights have been equipped with Lynx (apart from the three trial Sea King deployments mentioned above). Parent vessels – not all of which are simultaneously operative – are:

Type 82 destroyer: HMS *Bristol*

Type 42 destroyer: HMS *Birmingham*, *Cardiff*, *Edinburgh*, *Exeter*, *Glasgow*, *Gloucester*, *Liverpool*, *Manchester*, *Newcastle*, *Nottingham*, *Southampton* and *York*

Leander-class frigates: HMS *Andromeda*, *Argonaut*, *Ariadne*, *Charybdis*, *Cleopatra*, *Danae*, *Hermione*, *Jupiter*, *Minerva*, *Penelope*, *Phoebe*, *Scylla* and *Sirius*

Type 21 frigates: HMS *Active*, *Alacrity*, *Amazon*, *Ambuscade*, *Arrow* and *Avenger*

Type 22 frigates: HMS *Battleaxe*, *Beaver*, *Boxer*, *Brave*, *Broadsword*, *Brilliant*, *Brazen*, *Campbeltown*, *Chatham*, *Cornwall*, *Coventry*, *Cumberland*, *London* and *Sheffield* (accommodation for two Lynx)

Type 23 frigates: HMS *Norfolk* (and *Argyll* to follow)

Several other ships have helicopter platforms, including those for survey, ice patrol (HMS *Endurance* with two Lynx), supply and training.

Over 80 Lynx are available for service with No. 702 Squadron for training, and with the detached flights of Nos 815 and 829 Squadrons, all early HAS.Mk 2s have been upgraded to Mk

With the loss of large aircraft carriers, the Royal Navy w denied AEW coverage. This has been rectified by the S King AEW.Mk 2A, carrying a radar in an inflatable rado

No. 899 Sqn acts as a headquarters unit for the Sea Harrier force.

No. 849 Sqn, 'A' Flight, operates AEW Sea King from HMS Invincible.

The air defence partnership for Royal Navy carriers is t Sea King AEW.Mk 2A and Sea Harrier FRS.Mk 1. Close ordination between the two is regularly practised.

Standard small shipborne anti-submarine helicopter fo Royal Navy is the Lynx HAS.Mk 3. In addition to anti-submarine stores it can carry Sea Skua anti-ship missi

Royal Navy units do not wear much in the way of markings, usually carrying the squadron badge only.

The kingfisher badge o 829 Sqn used to adorn Wasps, but is now carri its Lynx helicopters.

Sea Harrier FRS.Mk 1s form the only front-line Royal Navy fixed-wing equipment, flying from HMS Invincible and Ark Royal. All will be upgraded to FRS.Mk 2 standard, with Blue Vixen radar and AMRAAM capability. This aircraft is from No. 800 Sqn, currently assigned to Invincible.

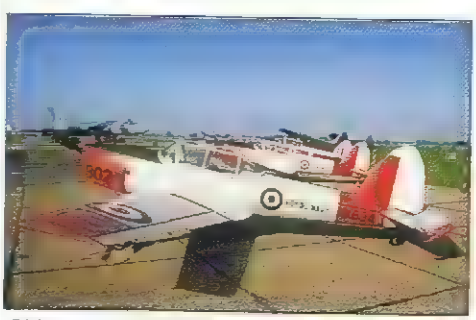
The flat-top dorsal radome identifies the Sea King HAS.Mk 5, the most common version in RN service. The type provides ASW coverage from larger ships.

Among No. 899 Sqn's inventory are five two-seat Harriers for training the Sea Harrier force. This is a T.Mk 4N.

The Westland Sea King HC.Mk 4 is distinguished by the lack of fuselage sponsons. It is used principally for marine assault, flying from the Navy's two assault ships.

Helicopter training for the Navy is accomplished at Culdrose, where sizeable numbers of Gazelles serve No. 706 Sqn.

Navigation and observation skills are taught by No. 750 Sqn using Jetstreams from Culdrose. T.Mk 2 (illustrated) and T.Mk 3 variants are in use.



Chipmunk T.Mk 10s serve in Navy colours on training and liaison duties. Units are the FGF, Yeovilton SF and No. 771 Sqn.

3 with more powerful engines. Just beg is a further modification to Mk 8, in wh Seaspray radar is repositioned in an und radome and its original position occupi thermal imaging sight with ×5 or ×30 fication for night operations. Further engines, a central tactical system and im ESM are also involved. Lynx may be with Sea Skua missiles for anti-ship attac their more normal role is in carrying Ml Stingray homing torpedoes or depth ch

Helicopter pilots receive initial train Bulldogs with the RAF before attendin 705 Squadron for instruction on W Gazelles. Type conversion follows with 706 Squadron for Sea Kings or No. 702 S ron for Lynx. Observers fly initially wit 750 Squadron's 15 Jetstream T.Mk 2s an T.Mk 3s (the latter with 360° radar unc fuselage in place of forward-scanning E.

Since Sea Devons and Sea Herons were drawn in December 1989, two Mk 3s hav detached to Yeovilton's Station Flight, o ing alongside two DHC Chipmunks Gazelle on liaison flights for FONA staf more Chipmunks are attached to the Bri Royal Naval College at Dartmouth as g trainers. Since 1989, Sea Harrier pilots ha ceived their type conversion with No Squadron, instead of at No. 233 OCU, radar training also at Yeovilton.

The Fleet Requirements and Air Dir Unit is operated by the civilian firm of Refuelling Ltd to exercise the Navy's operators, gunners and fighter controlle services are also called upon by the Yeov based RN School of Fighter Control. E ment comprises 16 civil-registered Dassau con 20s fitted with jamming, chaff and t towing pods; four BAC Canberra TT.M seven HS Hunter GA.Mk 11s, one PR.M two T.Mk 7s and nine T.Mk 8s. Among duties, the Hunters simulate sea-skim missiles fired against ships. Other jam services come from the RAF's No. 360 Sc ron, which has 25 per cent naval staff.

Major FAA repair and overhaul facilitie located at Fleetlands and Wroughton F Naval Aircraft Yards. Technical trainin time-expired airframes takes place at th Engineering School, Lee-on-Solent, an School of Aircraft Handling at Culdrose uses retired aircraft to train deck crews.

Fleet Air Arm Units

UNIT	EQUIPMENT	BASE

(Secondary types in parentheses)

Attack/interceptor/reconnaissance squadrons:

No. 800 Squadron	Sea Harrier FRS.Mk 1	HMS *Invincible*/ Yeovilton
No. 801 Squadron	Sea Harrier FRS.Mk 1	HMS *Ark Royal*/ Yeovilton
No. 899 Squadron	Sea Harrier FRS.Mk 1 (Harrier T.Mk 4A/4N) (Hunter T.Mk 8M)	

Anti-submarine squadrons:

No. 814 Squadron	Sea King HAS.Mk 5	HMS *Invincible*/ Culdrose
No. 819 Squadron	Sea King HAS.Mk 6	Prestwick
No. 820 Squadron	Sea King HAS.Mk 5/6	HMS *Ark Royal*/ Culdrose
No. 826 Squadron	Sea King HAS.Mk 5	Culdrose

ince the withdrawal of many FRADU Canberras, ECM aining is provided for the fleet by civilian Falcon 20s perated by Flight Refuelling Ltd.

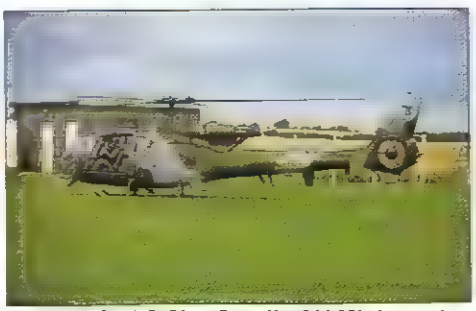
Canberra TT.Mk 18s still fly with FRADU, providing target tug duties for fleet gunners.

Not only is the Lynx a potent anti-armour weapon, it can also perform insertion missions, accommodating small numbers of troops or Milan teams in its cabin. Nap-of-the-earth flying is a speciality, keeping the helicopter hidden from enemy defences by using terrain and vegetation features.

The ageing Westland Scout AH.Mk 1 soldiers on with the AAC based at Netheravon. Its most important use is in the Far East, serving in both Hong Kong and Brunei.

Chipmunk T.Mk 10s provide initial training for AAC pilots from Middle Wallop. One aircraft is known as the 'Spitmunk'.

Two flights ('B' and 'C') of 3 CBAS fly the Lynx AH.Mk 1 in support of Royal Marines. These have the eight-TOW armament of the Army Lynx.



'A' Flt, 3 CBAS flies Gazelle AH.Mk 1 scout helicopters. These spot targets for artillery and the anti-armour Lynx.

Security forces in Northern Ireland are backed by 5 Regiment, whose No. 1 Flight was formed in 1989 with the first of seven PBN Defender AL.Mk 1s as replacements for the Beaver. The Defenders are understood to be equipped with several types of surveillance equipment. A new regiment forming at Dishforth supports 24 Air Mobile Brigade with the previously-mentioned Lynx AH.Mk 9s providing transport and acting as mobile command posts. Also included are No. 657 Squadron with TOW-armed Lynx and three Gazelles for wartime reinforcement of West Germany and five Gazelles of No. 3 Flight assigned to 2 Infantry Division.

Largest of the direct-reporting squadrons is No. 664 at Minden, Germany, with 12 liaison Gazelles for HQ 1(BR) Corps, a similar role for the benefit of HQ BAOR being performed by four more with No. 12 Flight at RAF Wildenrath. Gatow-based No. 7 Flight has three Gazelles at the disposal of the Berlin garrison. In Hong Kong, No. 660 Squadron has ten Scouts in the Crown Colony, plus three detached to Brunei, where they are used by the locally based Gurkha unit and jungle warfare training school.

British forces in Cyprus include three Gazelles of No. 16 Flight at Dekhelia and a similar number flying from Nicosia with the UNFICYP Flight in support of the United Nations peacekeeping force. The defence of Belize, in Central America, is aided by three Gazelles of No. 25 Flight; and another five with No. 25 Flight at Suffield in Canada are part of the BATUS (British Army Training Unit Suffield) battle exercise area.

Finally, the AAC Centre at Middle Wallop includes 24 Chipmunks for initial fixed-wing training. 20 Gazelles of the Basic Rotary Squadron and No. 670 Squadron (Advanced Rotary), and both Lynxes and borrowed Gazelles used by No. 671 Squadron for operational training, including Lynx type-conversion. Co-located No. 667 Squadron's role is better explained by its former title of Development & Trials Squadron.

Within the Royal Navy, 3 Commando Brigade Air Squadron at Yeovilton is responsible for supporting operations by the Royal Marine Commando – notably beach assaults from landing ships and reinforcement of Northern Norway, where exercises are held with the Sea King HC.Mk 4s of the FAA. Six Lynx armed with TOW provide anti-armour capability for 'B' Flight, and eight Gazelles shared between two flights are used for target observation, artillery direction, forward air control and liaison. 'HQ' and 'S' (support) Flights have no aircraft. The squadron includes 200 personnel, and its helicopters are maintained by army (REME) engineers.

AAC and RM Commando Units

SQUADRON	EQUIPMENT	BASE
Anti-armour squadrons:		
No. 651 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Hildesheim, FRG (1 Regt)
No. 652 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Hildesheim, FRG (1 Regt)
No. 653 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Soest, FRG (3 Regt)

No. 654 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Detmold, FRG (4 Regt)
No. 656 Squadron	Lynx AH.Mk 1/ Gazelle AH.Mk 1	Netheravon (7 Regt)
No. 657 Squdron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Dishforth (9 Regt)
No. 659 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Detmold, FRG (4 Regt)
No. 661 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Hildesheim, FRG (1 Regt)
No. 662 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Soest, FRG (3 Regt)
No. 663 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Soest, FRG (3 Regt)
No. 669 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Detmold, FRG (4 Regt)
Surveillance flight:		
No. 1 Flight	Defender AL.Mk 1	Aldergrove
Support units:		
No. 655 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Ballykelly (5 Regt)
No. 658 Squadron	Scout AH.Mk 1/Gazelle AH.Mk 1	Netheravon (7 Regt)
No. 660 Squadron	Scout AH.Mk 1	Sek Kong, Hong Kong 'C' Flight: Sena, Brunei
No. 664 Squadron	Gazelle AH.Mk 1	Minden, FRG
No. 665 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1	Aldergrove (5 Regt)
No. 666 Squadron	Scout AH.Mk 1	Netheravon (7 Regt)
No. 672 Squadron	Lynx AH.Mk 9	Dishforth (9 Regt)
(No. 673 Squadron	Lynx AH.Mk 9	forms 1991 in 9 Regt)
No. 8 Flight	A 109	Netheravon (7 Regt)
No. 16 Flight	Gazelle AH.Mk 1	Dekhelia, Cyprus
No. 25 Flight	Gazelle AH.Mk 1	Belize
No. 29 Flight	Gazelle AH.Mk 1	Suffield, Canada
UNFICYP Flt (1)	Gazelle AH.Mk 1	Nicosia, Cyprus
Liaison units:		
No. 2 Flight	Gazelle AH.Mk 1	Netheravon (7 Regt)
No. 3 Flight	Gazelle AH.Mk 1	Dishforth (9 Regt)
No. 7 Flight	Gazelle AH.Mk 1	Gatow, Berlin
No. 12 Flight	Gazelle AH.Mk 1	Wildenrath, FRG
HQ Flight	Lynx AH.Mk 1/Gazelle AH.Mk 1	Ballykelly (5 Regt)
Army Air Corps Centre:		
Chipmunk Sqn	Chipmunk T.Mk 10	Middle Wallop
BRS	Gazelle AH.Mk 1	Middle Wallop
No. 667 Squadron	Lynx AH.Mk 1/Gazelle AH.Mk 1/Scout AH.Mk 1	Middle Wallop
No. 670 Squadron	Gazelle AH.Mk 1	Middle Wallop
No. 671 Squadron	Gazelle AH.Mk 1	Middle Wallop
Historic Flt	Sioux AH.Mk 1, Alouette AH.Mk 2, Skeeter AOP.Mk 12, Auster AOP.Mk 9, Beaver AL.Mk 1	Middle Wallop
3 Commando Brigade Air Squadron:		
'A' Flight	Gazelle AH.Mk 1	Yeovilton
'B' Flight	Lynx AH.Mk 1	Yeovilton
'C' Flight	Gazelle AH.Mk 1	Yeovilton

Note: Several units – notably in West Germany – have at least some AH.Mk 7s in use. All Mk 1s are being converted to this standard.
(1) UN Forces in CYPrus (2) Basic Rotary Squadron

Fast-jet training for the Empire Test Pilots' School at Boscombe Down is provided by the Jaguar T.Mk 2. A Tornado F.Mk 2 is also available.

This elderly Beagle Basset CC.Mk 1 is used by the ETP for simulating variable stability aircraft. It is known as V-Stab Basset.

This Hunter serves with the A&AEE at Boscombe. It is to spray liquids to simulate chemical warfare attacks among other tasks.

Both the A&AEE (illustrated) and the RAE operate Pipe Navajo Chieftains in the communications role. The RA aircraft are in 'ripple' colour scheme.

Remarkably, this beautiful Vickers Varsity still flies on research tasks with RAE Farnborough. The ventral pan is filled with trials equipment.

Supporting Services

Aircraft of the armed forces are detached to – or sometimes specifically purchased for – units of the Ministry of Defence Procurement Executive, the MoD(PE). Those on the permanent fleet have mostly acquired a high-visibility 'raspberry ripple' colour scheme, but others retain service camouflage or a communications livery. Aircraft retained by the manufacturer for military-sponsored trials or development will often be in the service of the Controller of Aircraft, or C(A). The three principal supporting elements of the armed flying services are:

AEROPLANE & ARMAMENT EXPERIMENTAL ESTABLISHMENT

Based at Boscombe Down, the A&AEE concerns itself with the practical application of equipment and technology to warfare. New aircraft are assessed here before entering service and modifications similarly tested during the type's service career. About 30 resident aircraft are divided between two components: the Fixed-Wing Test Squadron (comprising 'A', 'B' and 'C' Flights) and the Rotary-Wing Test Squadron. Unusual types are two Harvards – the oldest aircraft in UK military service – a Comet 4 and a Navajo Chieftain.

ROYAL AEROSPACE ESTABLISHMENT

RAE aircraft are generally assigned to pure research programmes intended to extend the bounds of scientific knowledge. RAE facilities are Farnborough (including the Meteorological Research Flight), Bedford (Thurleigh and Cardington, including the former Royal Signals and Radar Establishment fleet), West Freugh (weapon ballistics), Aberporth (missiles), Llanbedr (pilotless aircraft) and Larkhill (land-based missiles). Aircraft types not used by the armed forces are the BAC 111, Comet 4, Viscount, Dakota, Navajo Chieftain (communications), Varsity, Meteor drone and Sea Vixen drone.

EMPIRE TEST PILOTS' SCHOOL

Almost a score of ETPS aircraft are based at Boscombe Down. Aircrew destined for flight-test duties with the A&AEE, the armed forces and some manufacturers pass through ETPS, as do students from many foreign countries. Unique aircraft types are restricted to a former RAF Basset, although this is expected to be replaced by a Hawk which has recently been modified with a fly-by-wire control system.

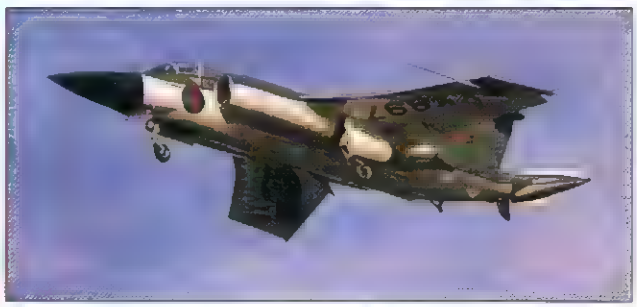
Test fleets of the aircraft and supporting industries include BAe's radar-nosed BAc 125; a Meteor Mk 7½ ejection seat testbed with Martin Baker; and a Lynx for engine trials with Rolls-Royce.

The ETPS Tornado F.Mk 2 has adopted this nose flash to identify the unit.

The A&AEE Fixed-Wing Test Squadron wears this badge on the fin.

A fleet of English Electric Canberras flies on research duties with the RAE from Bedford. The type has proved itself highly adaptable in the electronic role, and the majority of the test fleet are grossly modified to test advanced ECM/Elint equipment. This is a B.Mk 6.

This winged 'W' badge is proudly carried by the RAE Farnborough Varsity.



Another of RAE Bedford's varied test fleet is this Buccaneer, still wearing a Royal Navy colour scheme. It has a Tornado nose grafted on to the front.

Rotary-wing equipment of the RAE consists of a Wessex at Bedford, and a pair of Sea King Mk 4Xs at Farnborough. In the nose radome of this aircraft is the EH.101's radar.

BAC One-Elevens have been used for a variety of test purposes. This RAE Bedford aircraft has a Blue Vixen radar in the nose. Another serves with the ETPS.

The single Hercules W.Mk 2 is a grossly modified aircraft with a complete suite of meteorological instruments. It flies from Farnborough as part of the RAE.

Sandwiched between an RAE Bedford Viscount (now retired) and the ETPS Andover C.Mk 1 (with variable stability capability) is RAE Farnborough's superb Dakota, used mainly for transport duties.

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